ENVIRONMENTAL
RESEARCH & TECHNOLOGY
Technology Transfer Conference

FINAL PROGRAM and CONFERENCE PROCEEDINGS

Partnerships in Pollution Prevention

November 5 & 6, 1992
Metro Toronto Convention Centre
Toronto, Ontario
Canada

Ontario Environment Environnement

WELCOME

1992 TECHNOLOGY TRANSFER CONFERENCE

"Partnerships in Pollution Prevention"

Sponsored by

The Research and Technology Branch

Ontario Ministry of the Environment

Special thanks to:

- The Pollution Prevention Office, MOE
- The Ontario Ministry of Industry, Trade and Technology
- The Ontario Ministry of Natural Resources
- The Ontario Ministry of Northern Development and Mines

Welcome to the 1992 Technology Transfer Conference hosted by the Ontario Ministry of the Environment. The Ministry of the Environment plans this annual event to profile projects funded under The Environmental Research Program or the Environmental Technologies Program. This year, several enhancements to the conference structure will result in improved access to funding information, strategic directions of the Ministry and insights into specific environmental issues. As such, the event has progressed to become a major corporate event for the Ministry.

This year, to enhance the Ministry's focus on Pollution Prevention and the support of "green" technologies, the conference theme "Partnerships in Pollution Prevention" has been selected. Additions to the Conference include the Partners' Forum, Strategic Directions Workshops and a Dedicated Plenary Session.

The Partners' Forum is a networking opportunity for all delegates to meet with universities, industry associations, agencies who specialize in R&D, the private funding agencies and the government funding programs in an effort to develop partnerships and create strong new Ontario technologies. The Strategic Directions Workshops have been developed to provide assistance for submitting proposals, information regarding "changes to" and "future directions for" programs in the Ministry, as well as changes to the approvals process. Finally, the plenary session entitled "Pollution Prevention – from the Drawing Board to the Marketplace" will include speakers from government, industry and academia.

COMMITTEES

Helle Tosine – Conference Chair

Conference Committees

Advisory Committee

Anton Davies	Air and Waste Management Association (RWDI)
Bob Greven	Ministry of Energy
James Higgins	Canadian Environment Industry Association – Ontario Chapter (ETI)
Isobelle Heathcote	Pollution Control Association of Ontario (U of Guelph)
Ron Hunsinger	American Water Works Association – Ontario Section (MOE)
Ron Martin	University of Western Ontario
Jane Pagel	Ontario Hydro
David Reid	Ministry of Industry, Trade and Technology
Sharon Suter	Research and Technology Branch (MOE)
Peter Telford	Policy Development and Intergovernmental Relations (MOE)

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Sharon Suter (Chair)	Research and Technology Branch, Ministry of the Environment
Nilam Bedi	Fiscal Planning and Economic Analysis Branch, Ministry of the Environment
Bak Chauhan	Research and Technology Branch, Ministry of the Environment
Ray Clement	Laboratory Services Branch, Ministry of the Environment
Valerie Moraglia	Research and Technology Branch, Ministry of the Environment
Ron Nielsen	Waste Reduction Office, Ministry of the Environment
John Ralston	Water Resources Branch, Ministry of the Environment
David Reid	Consultant, Environmental Industries, Ministry of Industry, Trade and Technology
Neville Reid	Air Resources Branch, Ministry of the Environment
Susan Sheehan	Consultant, Environmental Industries, Ministry of Industry, Trade and Technology
Oksana Solomon	Research and Technology Branch, Ministry of the Environment
Terry Stopps	Pollution Prevention Office, Ministry of the Environment
Rôland Weiler	Hazardous Contaminants Branch, Ministry of the Environment

Organizing Committee

Sharon Suter (Chair)	Research and Technology Branch, Ministry of the Environment
Ana Rosati	Research and Technology Branch, Ministry of the Environment
Roger Scott	Research and Technology Branch, Ministry of the Environment
Barbara Kusznir	Research and Technology Branch, Ministry of the Environment
Jan Stein	Public Affairs / Communication Services Branch, Ministry of the Environment
Marjan Medved	Public Affairs / Communication Services Branch, Ministry of the Environment

Special thanks to Ana Rosati, Research and Technology Branch (MOE)

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The FINAL PROGRAM and CONFERENCE PROCEEDINGS consist of a final conference program, one page abstracts of presentations (where available), extended abstracts (3-4 pages) in wordperfect 5.1 on disk and any figures or tables (printed as an appendix in this document). The INDEX will list the page to find the abstract for each presentation and also the disk filename for extended abstracts.

DAY 1 THURSDAY, NOVEMBER 5, 1992

Constitution Hall (Room 105/106)	
8:45 a.m.	***OPENING:*** Conference Chair, Helle Tosine, Director, Research and Technology Branch
9:00 a.m.	***PLENARY SESSION:*** **Pollution Prevention — From the Drawing Board to the Marketplace;** Plenary Chair: Richard Dicerni, Deputy Minister of the Environment
9:10 a.m.	**Developing Ontario Environmental Industries;** The Honourable Ed Philip, Ontario Minister of Industry, Trade and Technology
9:30 a.m.	**Environmental Protection Using Pollution Prevention;** Eric Shaeffer, Director, Pollution Prevention Policy, Office of the Administrator, US-EPA
10:00 a.m. Coffee to be served	**Enhancing Industrial Competitiveness Using Pollution Prevention Planning — the Bottom Line;** Denis Wilcock, President and CEO, DOW Chemical Canada
10:30 a.m.	**From R&D to the Marketplace — Driving Technology Home;** Dr. Bill Fyfe, Professor Emeritus and former Dean of Science, University of Western Ontario
11:00 a.m.	***MINISTER'S ADDRESS:*** **Pollution Prevention and a Conserver Society;** The Honourable Ruth Grier, Ontario Minister of the Environment
11:15 a.m.	***THE PARTNERS' FORUM***
12:00 noon	***LUNCH***

DAY 1 THURSDAY, NOVEMBER 5, 1992

Theme: Location: Chairperson:	**SESSION 1** **GOVERNMENT FUNDING OPPORTUNITIES: PATHWAYS AND PARTNERSHIPS** *Reception Hall 104A* Doug Vallery, Research and Technology Branch, MOE	**SESSION 2** **SOIL REMEDIATION: CONTINUING CHALLENGES** *Reception Hall 104B* Stuart Bailey, Hazardous Contaminants Branch, MOE
1:00 p.m.	**A1** **PARTNERS' FORUM SESSION Pathways to The Environmental Technologies Application;** Doug Vallery*, Kirsten Mania, Program Manager, Research and Technology Branch, MOE	**B1** **Feature Speaker Challenges Facing the Application of New Remedial Technologies;** David Major*, Beak Consultants, Guelph, Ontario
1:20 p.m.	**A2** **Where to Get Federal Funding;** Robert Krauel, Simon Llewellyn and Kim Shikaze, Environment Canada, Toronto, Ontario	
1:40 p.m.	**A3** **Green Plan: "Technology for Environmental Solutions";** Derek Yue, Industry, Science and Technology Canada (ISTC), Toronto, Ontario	**B2** **Church Roofs and Smelters: Can We Model Soil Contaminant Migration?;** R. Ancoin; MOE, and M.I. Sheppard and J.L. Hawkins, Environmental Science Branch, AECL Research, Whiteshell Laboratories, Pinawa, Manitoba (ER 556C)
2:00 p.m.	**A4** **Partnerships for Environmental Technologies: 1. The Blue Bottle;** Dusanka Filipovic*, President, Halozone, Toronto, Ontario (ET273RS) **A5** **2. Technology Product Commercialization;** John Coburn*, President, Zenon Environmental Inc., Burlington, Ont.	**B3** **Use of Image Analysis Techniques to Determine a LNAPL Saturation Profile in a Sand Medium;** P.J. Van Geel* and J.F. Sykes, Department of Civil Engineering, University of Waterloo, Waterloo, Ontario (ER 541G)
2:20 p.m.	**A6** **3. Rayox Advanced Oxidation Products;** Adele Buckley*, Solarchem Environmental Systems Inc. (ET 024WS) **A7** **4. The EcoLogic Process;** Kelvin Campbell*, ELI-EcoLogic Int., Inc. **A8a** **5. Engine Control Systems;** Robert Faser, Newmarket, Ontario	**B4** **Field-Based Pilot-Scale Remediation Trials for Industrially-Contaminated Environmentally Hazardous Soils;** B.E. Holbein* and D.W. Hall, Tallon Metal Technologies Inc., Guelph, Ontario (ET 173WM)
2:40 p.m.	*COFFEE*	

SESSION 3 **ZEBRA MUSSELS: UPDATE ON THEIR CONTROL** *Reception Hall 104C* Judy Orendorff, Ministry of Natural Resources	SESSION 4 **STATE-OF-THE-ART ANALYSIS: SUPERCRITICAL FLUID EXTRACTION** *Reception Hall 104D* Eric Reiner, Laboratory Services Branch, MOE	**SPECIAL SESSION** **Pollution Prevention: Programs and Strategies for Industry and for Government** *Room 103B*
C1 **The Zebra Mussel Program: from Communications to Controls;** Judy Orendorff*, Ministry of Natural Resources, Maple, Ontario	**D1** **Feature Speaker** **Factors Controlling the Quantitative Supercritical Fluid Extraction of Environmental Samples;** Steven Hawthorne*, Energy & Environmental Research Center, University of North Dakota, Grand Forks, North Dakota, U.S.A.	***Session Chair:*** Terrance P. Stopps, Senior Advisor, Pollution Prevention Office, Ontario Ministry of the Environment. **SS1 1:00 p.m.** **Environmental Protection Program Northern Telecom; Eliminaton of Halogenated VOC and Waste Minimization.** Richard Quennville, Northern Telecom Canada Ltd. **SS2 1:20 p.m.** **Essex Specialty Products. Responsible Care for a Small Plant.** Dennis Burgin, Plant Manager, Essex Specialty Products. **SS3 1:40 p.m.** **Ontario's Pollution Prevention Initiatives and Development of a Comprehensive Strategy.** Adam Socha, Hazardous Contaminants Branch; George Crawford, John Hewings, Jim Smith and Terrance P. Stopps, Pollution Prevention Office, Ontario Ministry of the Environment. — Eliminating Specific Chemicals — Toxic Reduction Planning and Industrial Programs — Extending Industrial Success to a More Comprehensive Approach **The session will explore the 'formula for success' offered by pollution prevention, by examining some recently acclaimed industry accomplishments. Current Ministry initiatives and the development of other programs and a pollution prevention strategy, will also be considered.**
C2 **Potential Use Of U.V. Radiation as an Alternate Means of Zebra Mussel Control: Laboratory and Field Studies;** D. Lewis*, Aquatic Sciences Inc., St. Catherines, Ontario		
C3 **Effectiveness of Alum on Removal of Zebra Mussel Veliger Larvae form Raw Water Supplies;** G. Mackie* and B. Kilgour, MAWSA, Guelph, Ontario	**D2** **Important Factors in Enhancing Supercritical Fluid Extraction Efficiencies for Environmental Extraction;** J. Levy*, L. Dolata, A. Rosselli and R. Ravey, Technical and Customer Support, SUPREX Company, Pittsburgh, Pennsylvania	
C4 **Opportunistic Pathogenic Micro-organisms as Potential Control Agents of Zebra Mussels;** R. Mitchell* and J. Maki, Harvard University, Cambridge, Massachusetts	**D3** **Control of Extraction Rates and Recoveries in Supercritical Fluid Extraction;** J. Pawliszyn* and N. Alexandrou, Chemistry Department, University of Waterloo, Waterloo, Ontario	
C5 **Acute Lethal Effects of Hydrogen Ion on Adult Zebra Mussels;** R. McCauley*, Robert McCauley & Associates, Waterloo, Ontario	**D4** **Supercritical Fluid Extraction and Solid Phase Extraction Techniques Applied to the Analysis of Pulp and Paper Mill Effluents for 2,3,7,8-TCDD and 1,2,7,8/2,3,7,8-TCDF;** R.G. Peterson*, W.J. Luksemburg, J. Hedin, B. Silverbush, M. Werst, and N. Maloney, Alta Analytical Laboratory Inc., El Dorado Hills, California	

DAY 1 THURSDAY, NOVEMBER 5, 1992

Theme: Location: Chairperson:	**SESSION 5** **BUSINESS OPPORTUNITIES: IN ONTARIO AND ABROAD** *Reception Hall 104A* David Reid, Environmental Industries, MITT	**SESSION 6** **SOIL REMEDIATION: CHALLENGES AND POLICY** *Reception Hall 104B* Stuart Bailey, Hazardous Contaminants Branch, MOE
3:00 p.m.	**A8** **PARTNERS' FORUM SESSION The Financing of Environmental Industry Investment Opportunities;** James Higgins*, Environment Technologies Investment, Toronto, Ontario	**B5** **Oxidation of Perchloroethylene in Soil with Potassium Permanganate;** G.J. Farquhar* and M.J. Schnarr, Department of Civil Engineering, University of Waterloo, Waterloo, Ontario (ER 477G)
3:20 p.m.	**A9** **Exploring Financing for the Environmental Entrepreneur;** Michael B.C. Gundy*, President, Gundy and Associates Limited, Toronto, Ontario	**B6** **In-Situ/On-Site Bioremediation of Wood Treatment Soils Containing Chlorinated Phenols and PAHs;** A.G. Seech* and I.J. Marvan, Dearborn Chemical Co. Ltd., Subsidiary of W.R. Grace & Co., Mississauga, Ontario, and J.T. Trevors, Department of Environmental Biology, University of Guelph, Ontario (ET 212WM)
3:40 p.m.	**A10** **Ontario's Green Industry Strategy;** George Davies, Deputy Minister, Ministry of Energy	**B7** **Demonstration and Full-Scale Testing of a New Thermal Chemical Reduction Process for Remediation of Hamilton Harbour Sediments;** D. Hallett, EcoLogic Int. Inc., Rockwood, Ontario (ET 153WS)
4:00 p.m.	**A11** **Taking Advantage of Business Opportunities: The Strategic Alliance Approach;** John Aylings*, Trade and Investment Support Branch, Ontario Ministry of Industry, Trade and Technology, Toronto, Ontario	**B8** **Proposed Policy for Managing Excess Soil & Rock — How Does It Relate To Soil Remediation?;** B. Thorpe*, Hazardous Contaminants Branch, Ministry of Environment, Toronto, Ontario
4:20 p.m.	**A12** **Success Stories — Small Ontario Business Abroad;** *Introduction by:* Odette Corbu, ISTC, Toronto, Ontario *Presentation by:* Agglo Recovery Inc. Boojum Research Ltd.	**B9** **Progress Toward the Development of a National Protocol to Establish Soil Remediation Criteria;** L. Hofmann*, Hazardous Contaminants Branch, Ministry of Environment, Toronto, Ontario
4:45 p.m.	***PARTNER'S FORUM/MIXER***	
6:00 p.m.	***DINNER***	

SESSION 7 **TREATING MINE EFFLUENT: AN ECONOMIC OPPORTUNITY** *Reception Hall 104C* Richard W. Cowan, Ministry of Northern Development and Mines	SESSION 8 **STATE-OF-THE-ART ANALYSIS: SUPERCRITICAL FLUID EXTRACTION** *Reception Hall 104D* Eric Reiner, Laboratory Services Branch, MOE	**WORKSHOPS** *Room 103B*
C6 **National MEND (Mine Environment Neutral Drainage) Program and an Update on Ontario Initiatives (an effort to understand, manage and solve problems associated with the mining of sulphide deposits);** G. Feasby*, Canada Centre for Mineral and Energy Technology, Ottawa, Ontario, and H. Rabski, Ministry of Northern Development and Mines, Sudbury, Ontario	**D5** **Feature Speaker Extraction of Compounds of Environmental Interest from Soils, Sediments, Sludges and Tissues by Supercritical Fluid Extraction;** Bruce Richter*, J.L. Ezzell and N.L. Porter, Lee Scientific, Salt Lake City, Utah, U.S.A.	**W1** **3:00 p.m.** **Pollution Prevention: Facilities Assessment:** This workshop will provide participants with an introduction to the Pollution Prevention Planning Process including a tutorial on the process and method of preparing a Toxics Reduction Plan for a facility. Introductory presentations will provide a backdrop of current thinking, opportunities, successes, and barriers to the development and implementation of an effective planning process that encompasses reduction planning, inventory development and reporting options. The workshop will walk participants through a case study and development of a toxics reduction plan. *Facilitator:* George Crawford, Senior Advisor, Pollution Prevention Office *Workshop Leader:* Cam Metcalf, Pollution Prevention Training Manager Centre for Industrial Services University of Tennessee *Audience:* Maximum 60 people Pre-registration Only
C7 **Piloting of Cyanide Recovery for Re-use at an Ontario Gold Mill: Economic Feasibility for Widespread Application in the Gold Industry;** D.K. Kidby* and J.V. McCarthy, Jasmetech Metal Technologies Inc., Guelph, Ontario (ET 010WM)		
C8 **Decommissioning with Ecological Engineering;** M. Kalin*, Boojum Research Limited, Toronto, Ontario	**D6** **Direct Supercritical Fluid Extraction of Organics from Water;** S. Brewer* and P. Kruus, Centre for Analytical/Environmental Chemistry, Department of Chemistry, Carleton University, Ottawa, Ontario	
C9 **Development of a Microcomputer-Based Expert System for Mine/Mill Effluent Treatment Plant Design (Gold Industry Case);** B. Ou*, A. Zaidi and L. Whittle, Wastewater Technology Centre, Burlington, Ontario (ET 127WM)	**D7** **Combined Supercritical Fluid Extractor and Ion Mobility Detector for Selected Water Analysis;** F.E. Bales*, Pylon Electronics Inc., Ottawa, Ontario (ET 094AN)	
	D8 **Sampling, Supercritical Fluid Extraction and Gas Chromatography/Mass Spectral Analyses of Indoor Air Borne Carcinogens;** V.M. Kanagasbapahty, R.W. Bell, P. Yang, M.A. Lusis and R.E. Chapman, Air Resources Branch, Ministry of Environment, Toronto, Ontario, and Laboratory Services Branch, Ministry of Environment, Rexdale, Ontario (PDF 06)	
	Constitution Hall	
	Constitution Hall	

DAY 2 FRIDAY, NOVEMBER 6, 1992

Theme: Location: Chairperson:	SESSION 9 GROUNDWATER: A CRUCIAL RESOURCE *Reception Hall 104A* Ken Roberts, Water Resources Branch, MOE	SESSION 10 ANALYTICAL METHODS: NEW REFERENCE MATERIALS FOR QUALITY DATA *Reception Hall 104B* Don King, Laboratory Services Branch, MOE
9:00 a.m.	**A13** Feature Speaker **A Vision for Groundwater Management in Ontario;** Sam Singer*, Supervisor, Groundwater Management Unit, Water Resources Branch, MOE	**B10** Feature Speaker **Standards, Regulations, and Data Quality: The CAEAL Perspective;** Serge Villard*, President, The Canadian Association for Environmental Analytical Laboratories, Toronto, Ontario
9:20 a.m.		
9:40 a.m.	**A14** **University of Waterloo Rotosonic Borehole Drilling Program Geological Field Work and Lab Study;** G.V.R. Paloschi*, University of Waterloo, Waterloo, Ontario (ER 564G)	**B11** **Preparation and Use of a Real-Matrix Reference Material for Round Robin Study of Dioxin in Ambient Air;** C. Tashiro, Assistant General Manager, Wellington Environmental Consultants, Inc., Guelph, Ontario, and R.E. Clement*, P. Steer, M. Lusis, C. Chui, T. Dann, Ministry of the Environment and Environment Canada, Toronto, Ontario
10:00 a.m.	**A15** **Hydrogeology of the Oak Ridges Moraine;** K.W.F. Howard* and P.J. Smart, University of Toronto, Toronto, Ontario (ER 578G)	**B12** **Pilot Study For The Development of a Biological Certified Reference Material for Organochlorine Contaminants;** R. Guevremont*, K.W.M. Siu, P.S. Maxwell, C.A. Fraser, G.J. Gardner and S.S. Berman, Institute for Environmental Chemistry, National Research Council of Canada, Ottawa, Ontario (ER 570C)
10:20 a.m.	**A16** **Impact of Livestock Manure and Fertilizer Application on Nitrate Contamination of Groundwater;** D.L. Burton*, University of Guelph, Waterloo, Ontario (ER 488G)	**B13** **Standard Reference Aqueous Solutions for Highly Hydrophobic Materials Using the Generator Column Approach;** G. Foster-Roberts*, Zenon Environmental Laboratories, Burlington, Ontario
10:40 a.m.	*COFFEE*	

SESSION 11
TRANSPORTATION OF AIRBORNE TOXICS

Reception Hall 104C
Ed Piché, Air Resources Branch, MOE

C11 **Feature Speaker**
The Atmospheric Region of Influence for the Deposition of Pollutants to the Great Lakes Basin; Jim Young*, SENES Consultants, Richmond Hill, Ontario

C12 **Identification of the Locations of Trace Elements Found in Particles and Precipitation;** P.K. Hopke* and N. Gao, Department of Chemistry, Clarkson University, Potsdam, New York (ER 602G)

C13 **Efflux of Trace Greenhouse Gases for Agricultural Sites into the Atmoshphere;** C. Wager Riddle* and G.E. Kidd, Department of Land Resource Sciences, University of Guelph, Guelph, Ontario (ER 534G)

C14 **Health Effects of Air Pollution Assessed Using Ontario Health Survey Data;** L.D. Pengelly*, F. Silverman and C.H. Goldsmith, Institute of Environment and Health, McMaster University and University of Toronto, Hamilton, Ontario (ER 527G)

SESSION 12
PREVENTION AND REDUCTION OF SOLID WASTE: WHAT DO WE NEED TO KNOW?

Reception Hall 104D
Barbara Grant, Waste Reduction Office, MOE

D9 **Using Co-operative Approaches to develop Waste Reduction Programs;** Barbara Grant*, Diversion Analysis and Program Support, Waste Reduction Office, Ministry of the Environment, Toronto, Ontario

D10 **Feature Speaker**
The Quantity and Composition of Waste — Defining the Problem; Dr. Virginia MacLaren*, Geography Department, University of Toronto, Toronto, Ontario.

D10a **The Quantity and Composition of Waste — Defining the Problem;** Donald M. Gorber, SENES Consultants Ltd., Toronto, Ontario

D11 **Reduction, Reuse and Recycling: Why a Hierarchy?;** John Hanson, Executive Director, Recycling Council of Ontario, Toronto, Ontario.

D11a **What does a Hierarchy really mean?** Drew Blackwell, Assistant Deputy Minister, Waste Reduction Office, Ministry of the Environment, Toronto, Ontario

WORKSHOPS

Room 103B

W2 9:00 a.m.
Strategic Policy Directions for the Ministry of the Environment
The 1990's bring a shift in emphasis for environment ministries around the world — pollution prevention rather than pollution control, zero discharge of toxic chemicals rather than dilution and dispersion, waste minimization rather than simple waste management, public empowerment rather than public information, and so on. It is an opportune time to review strategic policy directions for the Ministry of the Environment and to explore the impact of new directions on the future mandate and role of the Ministry.
Facilitator: Ken Ogilvie
Policy Development & Intergovernmental Relations Divisions
Audience: Maximum 60 people
Pre-registration Only

W3 9:40 a.m.
The New Approval Process: How has it changed?
Several pieces of legislation including the Ontario Water Resources guidelines and regulations exist to assist the Ministry in fulfilling its responsibility for protecting the quality of our province's environment. To maintain control over environmental quality, these Acts require that approvals be obtained before the start of undertakings that may have an impact on the environment. Each year, the Ministry issues over 10,000 certificates of approval and permits in accordance with these Acts and regulations. In order to simplify procedures and ensures customer service, the Ministry is working on several fronts to streamline the approvals process. The Ministry's aim is to shorten the present turnaround time for certificates of approval and permits by 50% or more.
Facilitator: Wilfred Ng, Director, Approvals Branch
Audience: Maximum 60 people
Pre-Registration Only

DAY 2 FRIDAY, NOVEMBER 6, 1992

Theme: Location: Chairperson:	SESSION 13 GROUNDWATER REMEDIATION: PRACTICAL ASPECTS *Reception Hall 104A* George Hughes, Waste Management Branch, MOE	SESSION 14 ECONOMICS AND POLLUTION PREVENTION: CAN'T HAVE ONE WITHOUT THE OTHER *Reception Hall 104B* Prof. John Livernois, Department of Economics, University of Guelph
11:00 a.m.	**A17** **Feature Speaker** **Practicalities of Groundwater Remediation;** Ed Rodrigues*, Supervisor, Landfill Disposal Technology Unit, Waste Management Branch	**B14** **Pollution Prevention — "A Question of Dollars and Sense";** Jack Donnan*, John Hewings, Terrance Stopps and George Zegarac, Ontario Ministry of the Environment, Toronto, Ontario
11:20 a.m.		**B15** **Feature Speaker** **Emission Trading For Air Pollutants: An Economic Instrument for Moving Towards Pollution Prevention;** Albert Nichols, NERA Inc., Cambridge, Mass.
11:40 a.m.	**A18** **Microbial Transportation in Soils With and Without Macropores;** D.M. Joy*, University of Guelph, Guelph, Ontario (ER 547G)	**B16** **11:50 a.m.** **Pollution Prevention Through Economic Instruments: Learning From Experience; The Outcome of a 2 Day Workshop;** Jack Donnan*, Fiscal Planning and Economic Analysis Branch, Ontario Ministry of Environment, Toronto, Ontario
12:00 noon	**A19** **Direct Underwater Identification of Groundwater Discharge Zones Using Electrical Conductivity;** D.R. Lee*, Environmental Research Branch, Chalk River, Ontario	**B17** **12:10 p.m.** **Achieving Pollution Prevention Through Environmental Regulation: The Consequences of the Bill 220/90 Amendments to the Environmental Protection Act;** Glenna Ford*, Canadian Institute for Environmental Law & Policy, Toronto, Ontario, and Nilam Bedi, Ontario Ministry of Environment, Toronto, Ontario (ER 589C)
12:30 p.m.	***AWARDS LUNCHEON***	
1:30 p.m.	***PARTNERS' FORUM/COFFEE***	

SESSION 15 TRANSPORTATION OF AIRBORNE TOXICS *Reception Hall 104C* Ed Piché, Air Resources Branch, MOE	SESSION 16 PREVENTION AND REDUCTION OF SOLID WASTE: MATERIAL UTILIZATION STRATEGIES *Reception Hall 104D* Dennis Onn, Waste Reduction Office, MOE	WORKSHOPS *Room 103B*
C15 **Feature Speaker** **Trends in Toxic Chemicals in Herring Gulls from the Great Lakes;** Chuck Weseloh*, Canadian Wildlife Service, CCIW, Burlington, Ontario	**D13a** **Towards an Ontario 3Rs Strategy for Construction and Demolition;** Ira Greenspoon, Greenspoon Brothers Limited, Chair of the Environment Committee, Council of Ontario Construction Associations (COCA) **D13b** **Towards an Ontario 3Rs Strategy for Plastics;** Fred Edgecombe, Executive Director, Environment and Plastics Institute of Canada	**W4** **11:00 a.m.** **The Environmental Research Program: Research Needs and Opportunities** This workshop will provide participants with information on the new directions for Research under the Ministry's Environmental Research Program including, Ministry priorities, research needs and current and anticipated funding levels. Current initiatives with other Ministries, including joint funding for zebra mussels through the Ministry of Natural Resources and MEND-O with the Ministry of Northern Development and Mines will be presented. *Facilitator:* Bak Chauhan and Judy Keith Research and Technology Branch *Audience:* Maximum 60 people Pre-registration Only
C16 **Modelling the Influence of Buildings and Obstacles on Dense Gas Dispersion;** S.R. Ramsay* and R.E. Britter, Envirotech Research Ltd., London, Ontario (ER 528C)	**D13c** **Towards an Ontario 3Rs Strategy for Compostables;** Richard Caves, President, R. Caves and Associates Ltd.	
C17 **Measurements of Natural and Anthropogenic Volatile Organic Compounds in the Regional Atmosphere;** H. Niki*, B. Khouw, Z. Wu, T. Jobson, J. Lai, D. He and E. Tumber, Department of Chemistry, and Centre for Atmospheric Chemistry, York University, North York, Ontario (ER 530G)		
Constitution Hall		
Constitution Hall		

DAY 2 FRIDAY, NOVEMBER 6, 1992

Theme: Location: Chairperson:	**SESSION 17** **GROUNDWATER TECHNOLOGIES: Opportunities in ONTARIO and EUROPE** *Reception Hall 104A* Bob Gillham, Director, Waterloo Centre for Groundwater Research	**SESSION 18** **ECONOMICS AND POLLUTION PREVENTION: CAN'T HAVE ONE WITHOUT THE OTHER** *Reception Hall 104B* Nilam Bedi, Fiscal Planning and Economic Analysis, MOE
2:30 p.m.	**A21** **Metal Enhanced Degradation of Halogenated Organic Compounds;** S.F. O'Hannesin, Waterloo Centre for Groundwater Research, University of Waterloo, Waterloo, Ontario (ET 074WS)	**B18** **Environmental Restructuring of Ontario's Economy;** Bill Empey*, ARA Consulting, and Sharon Bailey, Ontario Ministry of Environment, Toronto, Ontario
2:50 p.m.	**A22** **Development of Sealable-Joint Sheet Pile Cutoff Walls for Groundwater Remediation;** R. Starr, Waterloo Centre for Groundwater Research, University of Waterloo, Waterloo, Ontario (ET 143WS)	**B19** **Capital Investment Cycles and Environmental Protection;** Avery Shenfeld, Ernst and Young, Toronto, Ontario, and Sean Southey*, Ontario Ministry of Environment, Toronto, Ontario (ER 550C)
3:10 p.m.	**A20** **Surface and Underground Water Quality in Ontario and the Four Motors for Europe — A Comparative Analysis;** Bob Gillham, Director, Waterloo Centre for Groundwater Research, Waterloo, Ontario	**B20** **Pollution Prevention Implications for Ontario's Environmental Protection Industry;** Avery Shenfeld*, Ernst and Young, Toronto, Ontario, and George Zegarac and Rohan Gaghadar, Ontario Ministry of Environment, Toronto, Ontario
3:30 p.m.	**A23** **Water Quality Issues in the Four Motor Regions (Italy, Spain, Germany and France);** Ken Richards, Intergovernmental Relations Office, MOE i) Lombardy, Italy ii) Catalonia, Spain iii) Baden/Württemberg, Germany iv) Rhône-Alpes, France Materials will be presented on the management of surface and underground water quality issues in the Four Motors for Europe and Ontario.	**B21** **Three Battlefronts in the War on Wastes: Paying for Waste Reduction and Recycling;** Erik F. Haites* and John J. Mapes, Barakat & Chamberlain, Toronto, Ontario
3:50 p.m.		**B22** **An Assessment of the Socio-Economic Impacts of Solid Waste Management Options in Ontario;** Murray Trott*, VHB Research and Consulting Inc., Toronto, Ontario, and Atif Kubursi, Econometric Research Limited, Oakville, Ontario, and Orna Salamon, Ontario Ministry of Environment, Toronto, Ontario

SESSION 19 **ANALYTICAL INSTRUMENTATION: ICP-MS — FAST, ACCURATE AND ULTRA-TRACE** *Reception Hall 104C* David Boomer, Laboratory Services Branch, MOE	SESSION 20 **HAZARDOUS WASTE MANAGEMENT THROUGH THE 90's** *Reception Hall 104D* Jim Smith, Pollution Prevention Office, MOE	**WORKSHOPS** *Room 103B*
C18 **Feature Speaker** **Sciex: From the Drawing Board to an International Company;** Barry French*, Institute for Aerospace Research, Downsview, Ontario	**D14** **Hazardous Waste Management and Prevention Planning;** George Rocoski*, Waste Management Policy, Waste Management Branch, Toronto, Ontario	**2:30 p.m.** **The F.W. Karasek Award Winner Presentation** **Long Range Transport of PCB's and other Organochlorines: Deposition, Bioaccumulation, and Biological Effects;** Derek Muir, Department of Fisheries and Oceans, Winnipeg, Manitoba
C19 **State-of-the-Art of Inductively Coupled Plasma-Mass Spectrometry;** A. Boorn*, Director, Analytical Instrumentation, Perkin Elmer Sciex Instruments, Thornhill, Ontario	**D15** **The First Step in Pollution Prevention: Quantifying and Characterizing Canadian Hazardous Wastes;** E. Cowan*, A. Veel and S. Hodgins, Apogee Research, Toronto, Ontario	**W5** **3:00 p.m.** **The Environmental Technology Program Application Form: Technical and Business Components** **Program:** *A. Environmental Technology Program Overview* *B. Commercial Program Information Requirements* *C. Application Approvals Process* *D. Discussion* *Program Leader:* Doug Vallery and Kirsten Mania, Environmental Technology Development, Ontario Ministry of the Environment *Business Consultant:* Susan Sheehan Environmental Protection Industries Consultant, Ontario Ministry of Industry, Trade and Technology *Audience:* Maximum 60 people Pre-registration Only
C20 **The Analysis of Lead in Soils by Electrothermal Vaporization Inductively Coupled Plasma Atomic Emission Spectrometry;** E. Salin* and C. Skinner, Department of Chemistry, McGill University, Montreal, Quebec (ER 504G)	**D16** **Development of Mercury — Free Reusable Alkaline Manganese Dioxide Zinc Consumer Batteries;** K. Tomantschger*, R.J. Book, R.D. Findlay, E. Dran, Battery Technologies, Mississauga, Ontario (ET 048RS)	
C21 **Determination of Hydride-Forming Elements: Past, Present, Future;** I.K. Brindle*, Chemistry Department, Brock University, St. Catharines, Ontario, and M. Chiba, Agriculture Canada, Vineland Station, Ontario	**D17** **Recycling of Printer's Ink: Applied Technology Provides Positive Environmental Impact;** A.A. Wakeford, ProActive Recycling Inc., Owen Sound, Ontario (ET 080RS)	
C22 **Instrumentation for Rapid Analysis of Toxic Elements by Inductively Coupled Plasma Spectrometry;** V. Karanassios*, Department of Chemistry, University of Waterloo, Waterloo, Ontario	**D18** **Development of a Novel Procedure to Disinfect Biomedical Waste;** P.L. Seyfried and M. Safer, University of Toronto, Toronto, Ontario (ER 544G)	

TECHNOLOGY TRANSFER CONFERENCE 1992
POSTER PRESENTATIONS

All Poster Presenters will be available for questions during the Dedicated Poster Session/Partners' Forum as follows:

Thurs., Nov. 5th, 1992 11:15 a.m. to 12:00 p.m. - All AP #'s
Thurs., Nov. 5th, 1992 4:45 p.m. to 6:00 p.m. - All BP #'s
Fri., Nov. 6th, 1992 1:30 p.m. to 2:30 p.m. - All Posters (AP #'s and BP #'s)

ENVIRONMENTAL TECHNOLOGY DEVELOPMENT

AP1 **Design, Evaluation and Marketing of a Modular Drinking Water Pilot Plant for the 1990's;** P.M. Huck, W.B. Anderson, Department of Civil Engineering, University of Waterloo, Waterloo, Ontario K.L. Edwards, Windsor Utilities Commission, Windsor, Ontario, T.E. Eyre, Brantford Public Utilities Commission, Brantford, Ontario, J.P. McNally, Regional Municipality of Ottawa-Carleton, Environmental Services Department, Ottawa, Ontario and R.B. Hunsinger, Ontario Ministry of the Environment, Drinking Water Section, Rexdale, Ontario (ET006WS)

BP1 **Development of Membrane Technology for Drinking Water Production: Treatment of Coloured Surface Waters;** A. Deutschmann, P.L. Côté and C. Smith, Zenon Environmental Inc., Burlington, Ontario (ET007WS)

AP2 **Advanced Oxidation and Reduction Technologies for Treatment of Contaminated Water;** J.R. Bolton, A. Buckley, S.R. Cater and A. Safarzedeh-Amiri, Solarchem Environment Systems, Richmond Hill, Ontario (ET024WS)

BP2 **Hard Metal, High Efficiency Sludge Handling Pump;** J.C. Hayward, Hayward Gordon, Mississauga, Ontario (ET036AWS)

AP3 **Development of A Nitrogen-Specific GC Detector For Measurement of Atmospheric Organic Nitrates;** P.B. Shepson and C. Hao, York University, North York, Ontario (ET066AN)

BP3 **Steam-Explosion Deinking of Xerographic WastePaper;** E.K.C. Yu, D.D'Agostino and M. Clarke, Stake Technology Management Inc., Burlington, Ontario (ET068RS)

AP4 **Expert System Software Development for Assessment of Solid Wastes Leaching and Disposal - Landis Expert System;** N. A. Billings, D. N. Young, Dearborn Chemical Company Ltd., Mississauga, Ontario (ET130WM)

BP4 **A Differential Optical Absorption Spectrometer (DOAS) for Environmental Monitoring;** S. Nadler, G.I. Mackay, and H.I. Schiff, Unisearch Association Inc., Concord, Ontario (ET136AP)

AP5 **An Expert System for Evaluating, Designing and Cost Efficient Management Systems for Gold Mines;** B. Ou, A. Zaidi and L. Whittle, Wastewater Technology Centre, Burlington, Ontario (ET127WM)

BP5 **Development of a Range of Waterloo Scrubber Products for Flue Gas Desulphurisation;** S.E. Mallett, Turbotak Technologies Inc., Waterloo, Ontario (ET205AAP)

AP6 **Preparing Thermoplastic Rubber Compounds Containing Ground Rubber Tires;** W.E. Baker, and P. Rajalingam, Queens University, Kingston, Ontario (ET226TT)

BP6 **Remote Vehicle Emission Sensing System: Feasibility Study;** A. Quaglia, Sciencetech, London, Ontario (ET237AP)

AP7 **Electric Vehicles and the Environment;** W.A. Adams, G.S. Song, Electrochemical Science and Technical Centre, University of Ottawa, and C.B. Prakash, Conservation and Proctection Branch, Environmental Canada, Ottawa, Ontario (ER549G)

BP7 **Demonstration of the ECO Logic Process of Highly Contaminated PCB Wastes;** K. Campbell, Eli-Eco Logic International Inc. Rockwood, Ontario (ET244WM)

AP8 **On Line Microwave Digestion for Environmental Samples;** A. Grillo, Questron Corporation, Princeton, N.J., P. Burgener, Questron Corporation, Toronto, Ontario, E. Salen, G. Legere, McGill University, Montreal, Quebec (ET265AN)

BP8 **The Ecodyne System: An Environmental Tool for Aquatic Studies;** V.S. Springthorpe & S.A. Sattar, University of Ottawa, Ottawa, Ontario

AP9 **Adding Value to Roads with Waste Plastics;** B. Harbinson, Polyphalt Inc., Toronto, Ontario

BP9 **Biofiltration of Toxic Metals from Acid Mine Drainage Through Actinorthizal Systems;** L. Chatarpaul and M. Kean, M. Kean Resources, Timmins, Ontario (ET175WM)

TREATMENT, PREVENTION AND REMEDIATION

AP10 **Removal of Selected Hydrocarbons from Soil Using Pseudomonas aeruginosa UG2 Biosurfactant;** M.I. Van Dyke, S.L. Gulley, H. Lee and J.T. Trevors, University of Guelph, Guelph, Ontario (ER496G)

BP10 **Genetic Engineering of Commercial Potato Cultivars for Virus Resistance;** M.G. AbouHaidar, H. Xu, H. Fakhrai and M. Eweida, University of Toronto, Toronto, Ontario (ER513G)

AP11 **Experimental and Theoretical Study of Guelph's Pilot Scale Solid Waste Composter. Data Aquisition and Temperature Feedback Control System;** L. Otten and R. Stuparyk, University of Guelph, Guelph, Ontario (ER501G)

BP11 **Bioconversion of MSW Paper to Fuel Ethanol: A Waste Reduction Project;** M. Wayman, University of Toronto, Toronto, Ontario (ER502G)

AP12 **Solid Waste Stabilization in a Landfill Environment;** J.W. Graydon and D.W. Kirk, University of Toronto, Toronto, Ontario (ER517G)

BP12 **Evaluation of the Capacity of Peat to Attenuate Landfill Leachate;** M.A. Warith, Golder Associates Ltd., Ottawa, Ontario, J.N. Dick, J.L. Richards & Associates Limited, Ottawa, Ontario and L. Fernandes, Faculty of Engineering, University of Ottawa, Ottawa, Ontario (ER536C)

AP13 **Modelling Liner-Leachate Compatibility;** R.J. Mitchell, Queen's University, Kingston, Ontario (ER537G)

BP13 **An Engineered Landfill Liner Utilizing Coal Fly Ash;** C.T. Nhan, D.W. Kirk and J.W. Graydon, University of Toronto, Toronto, Ontario (ER539G)

AP14 **Reduction of Nitrogen Losses From Animal Manures by Stabilization with Ammonium Adsorbing Minerals;** P. Van Straaten, D.L. Burton, and R.P. Voroney, University of Guelph, Guelph, Ontario (ER540G)

BP14 **Recovery of Hexavalent Chromium from Electroplating Waste Using Liquid Membrane Pertraction;** B.G. Fraser, M.W. Horn, M.D. Pritzker and R.L. Legge, University of Waterloo, Waterloo, Ontario (ER545G)

AP15 **In SITU Bioremediation of Halogenated Organics with a Novel Nutrient Injection Scheme;** J.F. Devlin and J.F. Barker, University of Waterloo, Waterloo, Ontario (ER546G)

BP15 **The Effectiveness of a Stormwater Management Pond in the Removal of Urban Contaminants from Stormwater;** W.E. Watt and J.D. Paine, Queen's University, Kingston, Ontario (ER491G)

AP16 **Solid Waste Production in Land Based Cultures of Rainbow Trout (oncorhynchus mykiss);** J. van Voorst, P.S. Chisholm, University of Guelph, Guelph, Ontario (ER516G)

BP16 **To Develop a Reliable, Economical and Environmentally Safe Method of Milkhouse Effluent Disposal;** M. Paulhus, Alfred College, Ministry of Agriculture, Alfred, Ontario (ER519G)

AP17 **Removal of Specific Pollutants by a Quasi Biological Procedure;** S. Brownstein, Brownstein Consultants, Lanark, Ontario (ER538C)

BP17 **Development of the Trap-Treat-Release Technique for Pesticide Minimized Termite Colony Control;** T.G. Myles, Faculty of Forestry, University of Toronto, Toronto, Ontario (ER553G)

AP18 **Documentation of the Biological Community of Polishing Ponds (Sutton concept Sewage Treatment System);** J.T. Graham, Henderson Paddon Environmental Inc., Owen Sound, Ontario (ER583C)

BP18 **Performance Review of Perforated Pipe-Grass Swale Stormwater Drainage System;** J.F. Sabourin and H. Abida, Paul Wisner and Associates, Ottawa, Ontario (ER585C)

AP19 **Benthic Invertebrates as Indicators of the Efficacy of a Heavy Metal Contaminants Cleanup;** M. Dickman and G. Rygiel, Brock University, St. Catharines, Ontario (ER586G)

TECHNOLOGY TRANSFER CONFERENCE 1992
POSTER PRESENTATIONS

ENVIRONMENTAL LEVELS & EFFECTS

BP19 **Induction of Toxicity of Polycyclic Aromatic Hydrocarbons by Sunlight: Photomodification of the Chemicals and Predictive QSARs;** B.M. Greenberg, D.G. Dixon, X.D. Huang, L. Ren, C.L. Duxbury and B.J. McConkey, University of Waterloo, Waterloo, Ontario (ER520G)

AP20 **Validation of Pulmonary Mutagenicity as an Index of Pulmonary Carcinogenicity;** J.A. Heddle, C. Urlando and K.S. Tao, York University, Toronto, Ontario (ER522G)

BP20 **Contingency Planning for Accidentally Released Genetically-Engineered Microorganisms (GEMs) in the Environment;** S.C. Jackman, H. Lee and J.T. Trevors, University of Guelph, Guelph, Ontario (ER552G)

AP21 **Mercury in Aquatic Food Webs;** D.J. McQueen, York University, Toronto, Ontario (ER576G)

BP21 **Receiving Water Environmental Effects Associated with Discharges from Ontario Pulp Mills;** G.J. Van Der Kraak, M.E. McMaster, University of Guelph, Guelph, Ontario, K.R. Munkittrick, M.R. Servos, Department of Fisheries and Oceans, Burlington, Ontario, C.B. Port, C. Port and Associates, Guelph, Ontario and M.R. van den Heuvel, University of Waterloo, Waterloo, Ontario (ER567G)

AP22 **Municipal Attitudes to Environmental Decisions, and the RAP Process in SE Ontario;** A. Crowder, S. Hendler, K. Leach, and D. Campfens, Queen's Centre for Sustainable Development, Queen's University, Kingston, Ontario

BP22 **Chromium Concentrations in Ontario Lakes; Speciation Methodology;** S.E. Beaubien and J.O. Nriagu, University of Waterloo, Waterloo, Ontario (ER580G)

AP23 **Source Profiles of Emissions from Residential Wood Burning in Ontario;** C.S. Davis and D.M. Dougherty, Concord Environmental Corporation, Downsview, Ontario (ER481C)

BP23 **Sugar Maple Decline and Corresponding Chemical Changes in Major Polymers in the Stem Tissue (Carbohydrates, Lignins, and Trace Element);** D.N. Roy and H.K. Mohamed, S.N. Pathak, University of Toronto, Toronto, Ontario (ER524G)

AP24 **Church Roofs and Smelters; Can We Model Soil Contaminant Migration;** M.I. Sheppard and J.L. Hawkins, Environmental Science Branch, AECL Research, Whiteshell Laboratories, Pinawa, Manitoba (ER556C)

BP24 **Research on Ultraviolet Radiation Monitoring and Forecasting Over Southern Ontario;** W.F.J. Evans, Trent University, Peterborough, Ontario (ER532G)

AP25 **In Situ Chemical Oxidation of Creosote Residuals;** S.P. Forsey, K.A.Hamilton, J.F. Barker, University of Waterloo, Waterloo, Ontario (ER542G)

TRANSPORT & FATE

BP25 **Soil Ingestion: An Inadvertent but Important Pathway;** S.C. Sheppard and W.G. Evenden, Environmental Science Branch, AECL Research, Pinawa, Manitoba (ER551C)

AP26 **Impacts of Solar Radiation on Polycyclic Aromatic Hydrocarbons: Photooxidation and Bioavailability;** B.M. Greenberg, D.G. Dixon, C.L. Duxbury, B.J. McConkey, X.D. Huang and L. Ren, University of Waterloo, Waterloo, Ontario (ER555G)

BP26 **Determination of the Integrity of Solid Wastes by Large Scale Leach Columns under Environmental and Controlled Conditions;** M. Modi and D.W. Kirk, University of Toronto, Toronto, Ontario (ER362G)

AP27 **Transport of Dissolved Contaminants in the Vadose Zone;** R.J. Mitchell, Queen's University, Kingston, Ontario (ER505G)

BP27 **Microbiological Indicators for Assessing Hydraulic Connection in Buried High Permeability Zones at Waste Disposal Sites;** M.A. Holder-Franklin and M. Sklash, Windsor University, Windsor, Ontario (ER543G)

AP28 **Groundwater Contamination From A Large Flux Septic System on Sand;** J. Harman, W.D. Robertson, and J.A. Cherry, University of Waterloo, Waterloo, Ontario (ER444G)

BP28 **An Overview of Trace Metal – Suspended Particulate Reactions in the Don River: The Influence of Sediment Geochemistry, Environmental Variables and Discharges to the System;** L.A. Warren and A.P. Zimmerman, University of Toronto, Toronto, Ontario (ER493G)

AP29 **Determination of Geochemical Modification of Groundwater Entering Surface Waters from a Industrial and Municpal Disposal Site;** D.R. Lee, University of Waterloo, Waterloo, Ontario (ER510G)

BP29 **Fluctuating Concentrations in Complex Terrain;** M.F. Lepage, M.D. Vanderheyden, A.E. Davies, Rowan Williams Davies & Irwin Inc., Guelph, Ontario (ER533C)

AP30 **Fate of Contaminants in Municipal Pollution Control Plants;** S. Hui and D. Mackay, University of Toronto, Toronto, Ontario (ER559G)

BP30 **The Importance of Fundamental Kinetics and Mechanism Studies in Understanding Photodegradation Process - an Overview;** J.R. Bolton, University of Western Ontario, London, Ontario (ER560G)

AP31 **Fate of Volatile Organic Compounds in Wastewater Collection Systems;** R.L. Corsi, G. Hayward, H. Lee, J. Bell, A. Whitmore, P. Martos, C. Quigley, University of Guelph, Guelph, Ontario (ER577G)

BP31 **Regionalization of Low Flow Characteristics in the Northeastern and Northwestern Regions;** H. Belore, D. Ashfield, R. Zhou, Cumming Cockburn Limited, Markham, Ontario (ER575C)

AP32 **Nitrate Persistance in Slightly Permeable Sdiments in Ontario;** B. Russell, W.D. Robertson, R.W. Gilham, and J.A. Cherry, University of Waterloo, Waterloo, Ontario (ER581G)

BP32 **Guelph Drainable Water Quality Management Model;** S.P. Singh, R.P. Rudra, W.T. Dickinson, University of Guelph, Guelph, Ontario (ER582G)

AP33 **Modelling the Influence of Topography on Dense gas Dispersion;** S.R. Ramsay and R.E. Britter, EnviroTech Research Limited, London, Ontario (ER479C)

BP33 **Kinetics of Sulfite Oxidation in the Presence of Airborne Particulates;** R.R. Martin, M. Giuliacci, T. Lee, T. Sylvester, University of Western Ontario, London, Ontario, J. Hipfner, P. Wong, Laboratory Services, Ontario Ministry of the Environment, Rexdale, Ontario (ER482G)

AP34 **Life History and Demographics of Zebra Mussel (DREISSENA POLYMORPHA) Populations in Lake St. Clair, Lake Erie and Lake Ontario;** D.A. Pathy and G.L. Mackie, University of Guelph, Guelph, Ontario (ER443G)

BP34 **Effects of Various Handling Procedures on Responses of Zebra Mussels in Bioassay Testing;** B. Kilgour, M.A. Baker, G. Mackie, MAWSA, Guelph, Ontario

BP35 **The Impact of Zebra Mussels (Dreissena polymorpha) on Populations of Unionid's Filtration Activity and Growth Rate;** P.L. Gillis and G.L. Mackie, Department of Zoology, University of Guelph, Guelph, Ontario

AP36 **Zebra Mussel Control Research: Product Testing for Small Water Intake Systems;** D. Lewis, Aquatic Sciences Inc., St. Catherines, Ontario

BP36 **A Long Range Transport Model with Nested Fine Resolution Grid;** M. Niewiadomski, The MEP Company, Markham, Ontario (ER529C)

AP37 **Studies of Oxidant Formation in Rural Areas of Ontario;** D.R. Hastie, P.B. Shepson and J.C. McConnell, York University, North York, Ontario (ER531G)

BP37 **Regional Scale Transport of Folatile Organic Compounds in the Subsurface;** D.J.V. Vliet, J.F. Sykes, and N.R. Thomson, Department of Civil Engineering, University of Waterloo,Waterloo, Ontario (ER541G)

ENVIRONMENTAL MEASUREMENT METHODS

AP38 **Remote Detection of Hydrocarbon Fuel Contaminants in the Subsurface;** J.D. Redman, S. DeRyck, J.P. Greenhouse and A.P. Annan and A.L.Endres, University of Waterloo, Waterloo, Ontario (ER561G)

BP38 **Evaluation of a Streptococcus Faecium Subsp. Casseliflavus Model to Assess Pollution Sources at the Kelso Conservation Area;** P.L. Seyfried, B.L. Xu and T. Bleier, University of Toronto, Toronto, Ontario (ER562G)

TECHNOLOGY TRANSFER CONFERENCE 1992
POSTER PRESENTATIONS

AP39 **The use of Body-Residue Based Modelling for Estimating the Toxicity of Toxicant Mixtures to Fish;** U. Klee, L.S. McCarty, CanTox Inc., Mississauga, Ontario and D.G. Dixon, University of Waterloo, Waterloo, Ontario (ER566G)

BP39 **Development of DNA Probe(s) for the Detection of Bifidobaterium Species in Water: Phase II;** J. Pang, V.L. Chan, H. Bingham and E. Hani, University of Toronto, Toronto, Ontario (ER573C)

AP40 **Basic and Applied Studies with a Trace Atmospheric Gas Analyzer;** R.J. Hughes and R.E. March, Trent University, Peterborough, Ontario (ER480G)

BP40 **Novel Bioassays For Soils;** S.C. Sheppard and W.G. Evenden, Environmental Science Branch, AECL Research, Pinawa, Manitoba, (ER525C)

AP41 **Development of a Hepatic Micronucleus Assay in Fish;** C.D. Metcalfe and C.R. Williams, Trent University, Peterborough, Ontario (ER429G)

BP41 **Standardized Rearing Materials and Procedures for Hexagenia, A Benthic Aquatic Bioassay Organism: Serial Dilution Bioassay for Sediment Toxicity Testing and Organism Calibration Testing;** J.J.H. Ciborowski, E.C. Hanes and L.D. Corkum, University of Windsor, Windsor, Ontario (ER450G)

AP42 **Chironomid Larvae as Potential Monitors of Sediment Genotoxicity;** J.J.H. Ciborowski*, L.A. Hudson and J. Whyte, University of Windsor, Windsor, Ontario

BP42 **The Use of Environmental Isotope Surveys in Assessing Contamination Potential for Confined Aquifers;** K. Chekiri and M.G. Sklash, University of Windsor, Windsor, Ontario (ER500G)

AP43 **Carcinogenicity Testing of Bleached Kraft Mill Effluent using in Vivo and in Vitro Assays;** C.D. Metcalfe and M.E. Nanni, Trent University, Peterborough, Ontario (ER521G)

BP43 **Development of Geographic Information System Application for Water Quality Management and Policy Development;** T. Cooper, H. Belore, Planners and Environmental Scientists, Markham, Ontario (ER584C)

AP44 **Are Lake Ontario Trout More Contaminanted Than Lake Trout from Inland Ontario Lakes?;** E. Bentzen, D.R.S. Lean and B.E. Hickle, Trent University, Peterborough, Ontario (PDF07G)

BP44 **AA-QC: A Quality Control Expert System and Its Interaction with AAcontrol and AAdiagnosis;** S. Lahiri and M.J. Stillman, University of Western, Ontario, London, Ontario (ER432G)

BP44A **Knowledge Development and System Design for SIRS: An Expert System for Use in Response to Emergency Chemical Spills;** Q. Zhu and M.J. Stillman, University of Western Ontario, London, Ontario (ER432G)

BP44B **Diagnostic Expert System: An ICON-Based Expert System for Diagnosis of Problem GC Data;** H. Du, S. Lahiri, G. Huang and M.J. Stillman, University of Western Ontario, London, Ontario (ER432G)

BP44C **Design, Coding and Implementation of Expert Systems in Environmental Chemistry;** M.J. Stillman, S. Lahiri, and G. Huang, University of Western Ontario, London, Ontario (ER432G)

AP45 **Automatable Total Cyanide Analysis;** L. Herrera, J. Graydon and D.W. Kirk, University of Toronto, Toronto, Ontario (ER497G)

BP45 **Surrogate Analysis of Trace Levels of Volatile Polar Organic Compounds in Drinking Water;** G.L. Hayward and Y. Si, University of Guelph, Guelph, Ontario (ER565G)

AP46 **Thermal Desorption of Solid Phase Extraction Columns for the Low Level Measurement of Organic Compounds in Water;** G.M. Charbonneau, W.G. Craig, B. Knight, and R.G. Walker, Paracel Laboratories Ltd., Ottawa, Ontario (ER569C)

BP46 **Microwave Based Horizon Techniques for Rapid Sample Digestion;** J. Guy Legere, McGill University, Montreal, Quebec (ER572G)

AP47 **Considerations for Ultra Trace Level Determinations in Flow Injection-Direct Sample Insertion ICP Spectrometry;** R. Rattray, J. Minoso, E.D. Salin, McGill University, Montreal Quebec (ER574G)

BP47 **The Measurement of Atmospheric Gases by Thermal Emission Spectroscopy;** W.F.J. Evans and E. Puckrin, Trent University, Peterborough, Ontario

TECHNOLOGY TRANSFER CONFERENCE 1992
POSTER PRESENTATIONS

AP48 **Analysis of Organic Compounds by Liquid Chromatography/Mass Spectrometry (LC/MS);** C.J. Koester, R.E March, Trent University, Peterborough, Ontario, D.T. Wang and V.Y. Taguchi, Laboratory Services Branch, Ministry of the Environment (PDF08)

BP48 **Stability of Polynuclear Aromatic Hydrocarbons in Chlorinated Drinking Water Samples;** P.W. Crozier, C.D. Hall, L. Gurprasad, L. Matchuk, Laboratory Services Branch, Ministry of the Environment and J. Yang, Shaanxi Environmental Monitoring, Central Station, Xi'ang, China

AP49 **Application of a Multidimensional Chromatographic/Mass Spectrometric Detection System to Trace Level Pesticide Analyses;** P.W. Crozier and C.D. Hall, Laboratory Services Branch, Ministry of the Environment

BP49 **Analysis of Sewage Sludge for 100 Organic Priority Pollutants at Parts Per Billion Levels;** R. Lega, J. Ladwig, O. Meresz, G. Crawford, D. Toner, Y. Jones and I. Ahmad, Laboratory Services, Ministry of the Environment

AP50 **Characteristic Levels of Chlorinated Dibenzo-p-dioxins and Chlorinated Dibenzofurans in Ontario Lakes;** K.A. MacPherson, A. Johnson, T.Kolic, A. Hayton, K. Taylor and E. Reiner, Laboratory Services Branch,Ministry of the Environment

BP50 **Development of a Near Real Time Continuous Mercury Analyzer;** A.C. Ng, G.B. Debrou, M.C. Corbridge, D.R. Schneeberger and F.H. Schaedlich, Air Resources Branch, Ministry of the Environment and Tekran Inc., Toronto, Ontario

AP51 **Non-Selective Detection of Mutations by Single Strand Conformational Polymorphism Analysis (SSCPA);** E. Fan, D.B. Levin and D.M. Logan, York University, North York, Ontario (ER554G)

BP51 **Determination of Rate Constants for the Aqueous Photodegradation of Pollutants by Hydrated Electrons Using a Spin Trap/EPR Method;** A.R. Hoy and J.R. Bolton, University of Western Ontario, London, Ontario (ER560G)

AP52 **Preliminary Studies of the Development of a High Performance Liquid Chromatography-Particle Beam-Mass Spectrometric Method for the Determination of PAH's;** R.P. Singh, I.D. Brindle, X. He, T.R.B. Jones and M. Miller, Brock University, St. Catharines; and M. Chiba, Agriculture Canada, Vinelane Station, Ontario

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DISCLAIMER

Please note that ER and ET numbers relate to the funded project number under either the Ministry's Environmental Research (ER) Program or the Environmental Technologies (ET) Program.

The views and ideas expressed in these presentations are those of the authors and do not necessarily reflect the views or policies of the Ontario Ministry of the Environment nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Translation of the presentations will not be provided. All sessions will be conducted in English.

PLEASE WEAR YOUR NAME BADGE AT ALL TIMES FOR ADMITTANCE INTO CONFERENCE FUNCTIONS.

PARTNERS' FORUM

PARTNERS' FORUM/DEDICATED POSTER SESSION – Constitution Hall

Thursday November 5, 1992 11:15 am – 12:00 pm
Thursday November 5, 1992 4:45 pm – 6:00 pm
Friday November 6, 1992 1:30 pm – 2:30 pm

Partners' Forum Participants:

GREAT LAKES POLLUTION PREVENTION CENTRE (Booth 1)

The Great Lakes Pollution Prevention Centre is one of three pollution prevention initiatives announced in the federal government's Green Plan. The Centre, located in Sarnia, was opened in May /92. It is a primary resource for the latest information on pollution prevention strategies including new technology, educational programs and success stories. The GLPPC mandate is to develop awareness of pollution prevention in the Great Lakes basin.

ORTECH INTERNATIONAL (Booth 2)

ORTECH International is a broadly based technical services enterprise dedicated to satisfying the needs of private and public sector organizations. ORTECH provides the highest quality services in product and process design and development, technical consulting, problem-solving, analysis, testing and evaluation, with emphasis on environmental, materials and transportation technologies.

More than 25 percent of ORTECH's 370 employees are directly involved in the delivery of environmental technical services in the following six categories:

- Monitoring Services
- Process Technology
- Environmental Consulting
- Analytical Services
- Environmentally-progressive Products

ENVIRONMENT CANADA (Booth 3)
TECHNOLOGY DEVELOPMENT BRANCH
Technology For Environmental Solutions

Through technology and commercialization programs, this initiative accelerates the development, demonstration and adoption of leading-edge environmental research and technology – in particular with other federal programs, universities, private laboratories and the environmental technology industry.

THE OTTAWA-CARLETON ECONOMIC DEVELOPMENT CORPORATION (Booth 4)

The Ottawa-Carleton Economic Development Corporation is a private, non-profit corporation committed to the economic expansion of the regional municipality of Ottawa-Carleton. The Corporation, with a membership of 430 private companies and the support of local government, has served as a catalyst to attract new business to the region.

The Ottawa-Carleton Economic Development Corporation's functions are:

1. To promote Ottawa-Carleton as an attractive place to invest and do business.
2. To assist in all aspects of location analysis including identification of building sites, consultation on labour and transportation, market studies, etc.
3. To provide access to local, provincial and federal government authorities and to financial institutions.
4. To encourage joint ventures with local firms.
5. To encourage the development of the region's infrastructure to meet the demands of the business community.

NATIONAL RESEARCH COUNCIL OF CANADA (Booth 5)
INSTITUTE FOR ENVIRONMENTAL CHEMISTRY

At the National Research Council's Institute for Environmental Chemistry (IEC) we are committed to improving, protecting and understanding the environment. We accomplish this by performing focused and relevant research and development, and by effectively transferring technology and knowledge to our industry clients and collaborators, and to our public

sector partners. Our linkages with industry lead to research and development collaborations and technology transfer opportunities and keep us informed of environmental issues and technical challenges. We are market- driven and responsive, and we recognize the importance of participating actively in the environmental sector and responding to the needs of both industry and the environment.

The growing demand to enhance or maintain industrial competitiveness and at the same time, to minimize adverse impacts on the environment, creates an opportunity for IEC to apply its scientific resources to address these complex issues through the creation of new science and technology. A scientific staff of 100 focuses its efforts and defining and addressing current and future environmental needs. IEC's business and technical staff work together to ensure the scientific effort is relevant, to identify research opportunities and to form technical collaborations with industry. The institute focuses on delivering the results of its scientific effort in the form of information, products, services and technology.

Technical Programs

Environmental Measurement Science (EMS) EMS targets its work to enhancing the efficacy of federal and provincial environmental monitoring and regulatory programs by developing chemical standards, analytical instrumentation and methodologies for measuring environmental contaminants.

Environmental Protection Science (EPS) EPS conducts focused scientific research and development to reduce or prevent the accumulation or discharge of unacceptable wastes.

Process Technology (PT) PT develops solutions to environmental problems through process design, adaptation and innovation.

SCIENCE AND PROFESSIONAL SERVICES DIRECTORATE (Booth 6)
UNSOLICITED PROPOSALS BROKERAGE SERVICE (UPBS)
AND ENVIRONMENTAL INNOVATION PROGRAM (EIP)

The Unsolicited Proposals Brokerage Service (UPBS) is a procurement brokerage service provided by Supply and Services Canada and designed to encourage innovative scientific and technological proposals. It provides an essential forum for federal, provincial, municipal and private sector organizations with limited R&D funds to leverage them with other groups carrying out related scientific research.

Environment Canada's Environmental Innovation Program (EIP) is designed to promote Canadian environmental innovation outside government and to strengthen environmental science and technology and is managed through the UPBS. It considers proposals which meet the objectives of the Green Plan, in the areas of natural sciences, social sciences, health sciences and humanities. To co-fund accepted proposals, an EIP fund of $18 million has been allocated over 5 years.

INDUSTRY, SCIENCE AND TECHNOLOGY CANADA (Booth 7)

Industry, Science and Technology Canada's mandate includes development and promotion of industry and science policies and programs to build a climate for sustainable long-term economic growth. Its Environmental Affairs Branch acts as the focal point to promote the technological capabilities of the environmental industry that enhance industrial competitiveness. It also ensures that environmental regulatory measures complement other government initiatives to strengthen the long-term international competitiveness of Canada's industrial sectors.

The Branch works with industry to identify and exploit business opportunities resulting from increasing concern over the environment and manages the Environmental Technology Commercialization Program which will provide direct financial assistance to alliances for first-time demonstration projects of new environmental technologies judged to be technically and commercially viable. The Canadian Office for Training in the Environment has recently been established to provide training opportunities.

CANADIAN HAZARDOUS MATERIALS MANAGEMENT, INC. (Booth 8)

Canadian Hazardous Materials Management, Inc. serves the information needs of Canada's waste generators regarding environmental regulations, compliance issues and new technologies that prevent pollution in air, water and soil. The safe management of toxic substances, emergency response and personal protection, waste transportation, treatment and disposal are subjects addressed in the bi-monthly magazine Hazardous Materials Management, the Compliance Monitor newsletter, and the Canadian Environmental Workshops training program.

Through its leadership in environmental trade associations, publications and training programs, Canadian Hazardous Materials Management promotes the development of Canada as a centre of excellence for environmental standards and pollution prevention technologies.

ROWAN WILLIAMS DAVIES & IRWIN INC. (RWDI) (Booth 9)

A consulting engineering firm specializing in environmental and microclimate studies. Since opening its offices in Guelph, Ontario in 1972, the firm has grown to approximately 65 employees.

Government agencies, industrial sectors and leading design firms are among RWDI's clientele. The firm provides consulting and research services for organizations throughout North America and the rest of the world.

An important aspect of the firm is the extent of its test facilities and human resources. The facilities include boundary layer wind tunnels and open channel water flume and fume hood testing laboratories, in-house model shop, integrated data acquisition, storage and processing systems, computer aided drafting and a broad base of specialized instrumentation. The laboratories are supported by a team of engineers, meteorologists, engineering technologists and technicians. These resources allow us to offer a wide variety of services ranging from consultations to the indepth model studies for clients through the world.

MINISTRY OF INDUSTRY, TRADE AND TECHNOLOGY (Booth 10)

Mandate:

- to foster and assist in the retention, start-up, operation and expansion of business in Ontario
- to stimulate business investment in Ontario
- to assist Ontario companies in entering and competing successfully in national and international markets
- to provide relevant and timely information and advice to the

Government of Ontario in support of industry, trade and technology to stimulate increased productivity through the development and application of technology to develop sectoral strategies for sectors where MITT has lead responsibility and to support ministries with sectoral responsibilities.

MITT operates a network of 18 domestic and 17 international offices that provide services ranging from providing access to government programs, business advisory services, international export advice and trade and investment promotion through numerous programs.

MITT's Agencies:

1. Technology Ontario is a $1 billion, 10 year commitment to promote the use of science and technology to make industry more competitive.
2. The Development Corporations of Ontario, either directly or as agents for other Ministries, provide financial assistance to businesses throughout the province.
3. Ontario International Corporation assists in the marketing of Ontario professional services and capital goods to penetrate export markets and win contracts for specific projects.
4. ORTECH International is a broadly based technical services enterprise, dedicated to satisfying the needs of private and public sector organizations.
5. Ontario Aerospace Corporation coordinates activities related to Dehavilland Aircraft.

THE CANADIAN INDUSTRIAL INNOVATION CENTRE/WATERLOO (Booth 11)

The Canadian Industrial Innovation Centre/Waterloo is a not-for- profit organization associated with the University of Waterloo and partially funded by the federal government. Most known for our assistance to Canadian inventors, the Innovation Centre has evaluated over 7,000 new product ideas and helped over 30,000 Canadian inventors. Our complete service line to innovators, inventors and entrepreneurs include: idea evaluation, product design, development and testing, market research, books for innovators, education programs, and, specific to the interests of this conference, an international technology transfer database system.

Called the World Bank of Licensable Technology, this international database has over 20,000 technologies listed as available for license. International sites are located in the USA, Canada, Germany, Czechoslovakia, Japan, China and Russia.

ONTARIO MINISTRY OF ENERGY (Booth 12)

The Ministry of Energy has a range of programs from R&D to retrofit of existing equipment to help Ontario's manufacturing sector improve its competitive advantage. The emphasis is on energy efficiency in industrial equipment and processes. Programs are enhanced to support the development of Ontario's Green Industry.

BROCK UNIVERSITY (Booth 13)

Brock University opened its doors in 1964. Located in St. Catharines, on the brow of the Niagara escarpment, Brock has grown into a mid-sized university with six faculties and a number of inter-disciplinary programs. Through the years, Brock has nurtured its commitment to offer a broadly based liberal undergraduate education with an emphasis on small-group learning and easy access and communication between students and faculty. Research activities grew concurrently with the University's progress. The Faculty of Mathematics and Science comprises the departments of Biological Sciences, Chemistry, Computer Sciences, Geology, Mathematics and Physics. Research is pursued in all departments and graduate programmes leading to the Master of Science degree are offered in Biology, Chemistry, Geology and Physics. An existing Environmental Science programme is currently being updated; it involves the departments of Biology, Chemistry and Geology as well as the Institute for Urban and Environmental Studies.

Since 1991, the Brock Science Partnerships initiative has focused on promoting collaboration between the members of the Faculty of Mathematics and Science and the private sector. For a business enterprise, collaboration allows access to a knowledge base which usually cannot be sustained by each individual organization, in effect permitting alternate pathways to R&D consulting. For university researchers, it opens new horizons, keeps teaching programs actual and creates opportunities for joint research. In conjunction with fulfilling the University's primary mandate for education, the Science Partnerships programme is envisaged as the vehicle of choice for the continuation of Brock's service to the community through excellence in education and relevance of professional training.

OFFICE OF POLLUTION PREVENTION, CENTRE FOR INDUSTRIAL SERVICES UNIVERSITY OF TENNESSEE (Booth 14)

The Centre provides training and instruction to industrial facilities in the development and delivery of a variety of pollution prevention initiatives. The Centre staffs several experienced managers who have excelled in waste reduction activities, facility assessments, and the organization of training sessions and workshops. Mr. Cam Metcalf from the Centre will facilitate a conference workshop entitled "Pollution Prevention – facilities assessment" and will be available to discuss the U.S. experience.

THE ONTARIO DEVELOPMENT CORPORATION (Booth 15)

The Development Corporations of Ontario are crown agencies of Ontario's Ministry of Industry, Trade and Technology. They were established to encourage the development and diversification of industry including tourism, by providing financial assistance to Ontario based businesses.

The four Corporations specialize in meeting the regional economic needs of businesses throughout the province.

- Ontario Development Corporation (ODC) serving central and southwestern Ontario
- Northern Ontario Development Corporation (NODC) serving northern Ontario
- Eastern Ontario Development Corporation (EODC) serving eastern Ontario
- Innovation Ontario Corporation serving technology-based companies throughout Ontario

Together, the Corporations lead the efforts of the Ontario Government to boost business and industrial development in the province. Economic development programs of other ministries and agencies are also delivered by the Corporations. In addition, the Corporations manage selected provincial investments in commercial enterprises and operate two industrial parks.

The Development Corporations of Ontario use a range of financial instruments to assist industry. Loans and loan guarantees with attractive terms and conditions are available through the regional Development Corporations (ODC, NODC, and EODC), Innovation Ontario provides equity and quasi-equity investments to assist technology-based businesses. The loans and loan guarantees can be integrated into a larger financial package involving traditional bank borrowing, as well as equity financing. What distinguishes the Corporations from other lenders is their willingness to be involved with higher-risk enterprises that promise long-term economic benefits to Ontario. The Corporations offer competitive interest rates, and favourable terms of repayment and borrowing conditions.

INNOVATION ONTARIO CORPORATION

Established in 1966, Innovation Ontario Corporation's primary purpose is the development of early stage, technology based businesses to a point where they can attract private sector investment sufficient to ensure sustained growth and profitability. To achieve this goal, Innovation Ontario makes venture capital investments in technology based companies; it does not provide grants or loans.

Generally, Innovation Ontario employs one of two financial instruments when it participates in a business, namely:

- Share Purchase where Innovation Ontario's investment is used to purchase a percentage of the ownership of the business;

  or,

- Royalty Agreements where in exchange for Innovation Ontario's investment the company agrees to pay Innovation Ontario a percentage of its sales revenue.

The considerations made by Innovation Ontario before investing in a company closely parallel those of private sector venture capitalists but with added flexibility appropriate to the phase of development demonstrated by each individual client.

Since Innovation Ontario participates financially in many different types of projects at various stages of development, no standard application form is possible. In lieu of a standard application form, a business plan should be submitted for assessment and consideration by Innovation Ontario.

THE GREAT LAKES CLEANUP FUND (Booth 16 and 17)
ENVIRONMENT CANADA

The Cleanup Fund is one component of the federal government's Great Lakes Action Plan launched in the Fall of 1989 to aid restoration of Great Lakes water quality in the 17 Canadian Areas of Concern. An ecosystem approach and a strong element of cooperation are key principles embraced by the Fund. Depending on the nature of a particular project, contributors may include federal, provincial, or municipal agencies as well as industry and interest groups.

Remedial Action Plans (RAPs) are being developed by Remedial Action Plan teams and Public Advisory Committees in an effort to restore beneficial water uses to each of the 17 Canadian Areas of Concern. Projects supported by the Cleanup Fund may, depending on their applicability, be used in fulfilling RAP goals. Funding is provided for the assessment, removal and treatment of contaminated development and demonstration of innovative wastewater treatment technology for the control of urban runoff, and controlling rural non-point sources of pollution.

WASTEWATER TECHNOLOGY CENTRE (Booth 18)

Established in 1972 by Environment Canada as a research and development laboratory, the Wastewater Technology Centre (WTC) has become the foremost Canadian facility in the development and evaluation of treatment and disposal technology for municipal and industrial wastewaters and associated residues. It also fulfils a prominent role in international trade and scientific negotiations that focus on these areas of technology development. Current investigations emphasize the development of innovative wastewater treatment and process technologies, waste minimization, the optimization of pollution control systems and the application of site remediation technology.

In 1991, the government-owned WTC came under the contractual supervision of RockCliffe Research Management Inc. In addition to providing support to government programs and priorities, the WTC is now better positioned to develop and commercialize innovative technology in support of Canada's environmental protection needs.

TORONTO VENTURE GROUP (Booth 19)

The mission of TVG is to develop positive, high-growth venture deal flow by facilitating education, communication and networking.

TVG is a non-profit enterprise. By becoming a subscriber, individuals and organizations enjoy easy access to the monthly forums as well as recognition for supporting a unique, innovative and effective initiative within the Metro Toronto region.

We believe that the most difficult hurdle facing start-up businesses is finding the right financing and support. We are committed to keeping entrepreneurial business people informed and connected to others who share their venture spirit.

TVG's monthly breakfast meetings are designed for business people who know that time is of the essence. The meetings begin at 7:30 a.m. and end promptly at 9:30 a.m.

TVG features high-profile, knowledgeable and insightful speakers who are successful business people, investors and service professionals. Topics focus on venture investing and include: case histories, methodologies and economic developments. Attendants meet and exchange ideas with the movers and shakers of Canada's venture industry.

WATERLOO CENTRE FOR GROUNDWATER RESEARCH (Booth 20)

Waterloo Centre for Groundwater Research has been formally designated as one of the seven Ontario Centres of Excellence. With operations based at the University of Waterloo, the Centre has 26 members, all of whom are faculty appointments in one of five University Departments (Earth Sciences, Biology, Chemistry, Civil Engineering, and Urban and Regional Planning), and seven Industrial Associates, all of which are Ontario-based companies with an active presence in the groundwater technology industry. The research program is wide in scope, and deals in a broad sense with issues pertaining to the development and protection of groundwater resources and the impacts of modern human activity on subsurface environmental quality. With multidisciplinary contributions from the earth, physical, and mathematical sciences, the Centre conducts research primarily in six theme areas including:

- remediation of contaminated groundwater
- behaviour of organic contaminants in groundwater
- evaluation and development of groundwater resources
- groundwater protection
- hydrogeologic aspects of waste management
- mine environment research

The Centre promotes the development of the Ontario advanced- technology groundwater industry, and fosters international awareness of Ontario and Canadian groundwater technology and expertise.

ONTARIO CENTRE FOR MATERIALS RESEARCH (Booth 21)

The Ontario Centre for Materials Research promotes world leadership in the development of materials knowledge in Ontario through research and the transference of knowledge and technology to industry. The Centre funds industrially relevant research at Ontario Universities in: polymers and plastics, biomaterials, metals and ceramics, electronic and optoelectronic materials, and in films, surfaces and coatings. To complement this research, the Centre supports a range of technology transfer activities.

AWWA RESEARCH FOUNDATION (Booth 22)

The Research Foundation was established in 1966. Its mission is to sponsor practical applied research on behalf of the North American Drinking Water Industry. The Research Program embraces all aspects of water resources, treatment technologies, water quality, storage and distribution operations, health effects studies, and utility management.

The Foundation is funded by voluntary investment in research by over 550 water utilities in the US, Canada, the UK and France. Support level is based upon water production. Support is also provided by consulting firms. The Foundation has sponsored research projects worth well over $50 million. This budget has supported over 220 research projects, 90 of which are completed with final reports available.

AIR AND WASTE MANAGEMENT ASSOCIATION (Booth 23)

The Air and Waste Management Association is a non-profit, technical and educational organization with more than 12,000 members in over 50 countries. Founded in 1907, the Association provides a neutral forum where all viewpoints of an environmental management issue (technical, scientific, economic, social, political, and public health) receive equal consideration. The technical scope of the Association has three parts: Air pollution effects and control; Environmental management; Waste processing and control.

The Ontario Section of the AWMA has over 600 members. The membership is comprised of professional and technical people in industry, government and consulting. Each year the Ontario Section provides a spring meeting (this year in Guelph, April 26-29), a fall meeting (usually at a local resort) and three dinner meetings. These forums provide opportunities to meet people in the environmental field and to exchange the latest technical and professional information.

CANADA CENTRE FOR MINERAL AND ENERGY TECHNOLOGY (Booth 24)
(CANMET)

The Canada Centre for Mineral and Energy Technology (CANMET) is the main research and development arm of Energy, Mines and Resources Canada. Through exploratory research, commercial and cost-shared R&D, product testing and technology transfer, CANMET assists Canada's minerals, metals and energy industries.

CANMET's mission is to work in partnership with its clients to enhance the competitiveness of the Canadian minerals, metals and energy industries, to improve and develop energy efficiency and alternative energy technologies, to improve health, safety and environmental control in client industries and to support government policy initiatives.

MINE ENVIRONMENTAL NEUTRAL DRAINAGE (MEND) (Booth 26)

A subset of mining sites in Ontario have waste rock, tailings (mill wastes) and mine workings that generate acidic drainage. The low pH associated with the reaction solubilizes toxic metals which are carried off the property. During operations, acids are neutralized to prevent impairment of water courses. After mine closure is initiated techniques are required to treat or manage the problem.

In 1988, spurred by industry, a national research organization called MEND was established to oversee and coordinate research into acid mine drainage. In Ontario, research efforts related to acid mine drainage have been attended through an industry/government/university committee called MEND-Ontario (MEND-O). MEND-O works in close cooperation with the national body to ensure that overall goals are met. The MEND program is estimated to cost $18 million with a completion date of 1997. Projects fulfilling the objectives of the Program may receive financial support through the various participants.

YORK UNIVERSITY (Booth 27)
TECHNOLOGY TRANSFER OFFICE, INNOVATION YORK

Facilitates the interaction of faculty with industry. The centre monitors patent applications on behalf of York University and its affiliated Institute for Space and Terrestrial Science (an Ontario Centre of Excellence). Innovation York also assists the commercialization of intellectual property and innovations arising from research, an activity which has led to several spinoff ventures being developed during the past five years. Another source of transfer is effected by the placement of senior undergraduates in high tech companies as part of the Faculty of Pure & Applied Science Program. As well, an Industrial Technology Advisor (ITA) of the National Research Council is located at the centre to assist industry through the federal government's IRAP program.

ONTARIO HYDRO RESEARCH DIVISION (Booth 28)

A pioneer in electric utility research in North America, the Research Division of Ontario Hydro has, from its modest beginning in 1912, grown into a laboratory that employs over 650 employees and that has attained a leading position in several technical fields. The Research Division is made up of nine departments. Chemical Research, Civil Research, Divisional Projects, Divisional Services, Environmental Sciences, Electrical Research, Mechanical Research, Metallurgical Research, and Operations Research.

Environmental Sciences Department

The Environmental Sciences Department was established on September 3, 1991. The Department has a dual role. Firstly, it provides new scientific knowledge and technology about the sources of environmental problems, their modes of action and significance, and develops appropriate mitigation measures. This new knowledge and these new technologies are required by other units in the Corporation so that they can meet their environmental responsibilities in the most cost effective manner possible. Secondly, the Department provides technical support for other Corporate programs that are also addressing environmental issues. The Environmental Sciences Department is divided into three sections with a staff complement of approximately 52.

AWARDS PRESENTATIONS

Awards Presentations:

Friday November 6, 1992 – 12:30 pm Constitution Hall
Presentations by The Honourable Ruth Grier, Minister of the Environment

MINISTRY OF THE ENVIRONMENT EXCELLENCE IN RESEARCH and TECHNOLOGY DEVELOPMENT AWARDS

Principal Investigator Awards

These awards are presented to selected principal investigators of research projects funded through the Research Advisory Committee and technology development projects funded through the Environmental Technologies Advisory Committee.

In presenting these awards, the Ministry recognizes both the principal researchers and their institutions. Each award recipient receives a citation and a sum of $1,000.00, while their institution receives a plaque in recognition of the support and encouragement given throughout the project.

1992 WINNERS:

Dr. C.D. Metcalfe	Trent University
Prof. J.C. Sutton	University of Guelph

Student Awards

Awards of Excellence will be presented to selected students or graduates of Ontario Universities. The award is instituted by Environment Ontario to encourage students to undertake research and technology development in the field of environmental science and technology. The student will receive a citation and a sum of $1,000.00, while their institution receives a plaque in recognition of the support and encouragement given throughout the project.

1992 WINNERS:

Donald Jackson	University of Toronto
David McLaughlin	University of Toronto
Iris Albrecht	University of Waterloo

Staff Achievement Award

The Staff Achievement Award will be presented to selected Ministry staff to acknowledge their accomplishments in environmental research, environmental technologies, project management or outstanding liaison activities.

Successful staff receive a citation of excellence and a sum of $500.

1992 WINNERS:

Norman D. Yan	Water Resources Branch
Ljuba Simovic	Water Resources Branch
Andy Ng	Air Resources Branch

Ministry of the Environment Poster Award (NEW)

For the first time MOE will award a plaque to the poster presenter for excellence in poster preparation and presentation. The poster will be judged by conference delegates by ballot cast at the close of day one of the conference. The Award will be presented by the Honourable Ruth Grier, Minister of the Environment at the Awards Luncheon on Friday, November 6th, 1992. Posters will be judged on technical and organizational merits as well as visual impact.

KARASEK AWARDS

The Francis W. Karasek Award for Achievement in Environmental Science is given for overall accomplishments in the field. These can include analytical, physical or biological contributions. The criteria will include scientific publications, participation in conferences, contributions to science and the beneficial influence on other scientists.

The recipient will be presented with the award by Dr. Francis Karasek at the Friday November 6th luncheon.

AWARDS PRESENTATIONS

A presentation will be given by the award recipient following the luncheon in room 103B.

The award consists of $1,000 and a diploma.

1992 WINNER:

Derek Muir, Department of Fisheries and Oceans, Winnipeg, Manitoba

OWMC WASTE REDUCTION AWARD

The OWMC Outstanding Waste Reduction Achievement Award was introduced to encourage Ontario industrial firms to undertake waste minimization measures.

A panel of five waste management experts representing industry, government, scientists and the media will evaluate all applications and make the final selection. Awards are based on:

- Quantity and toxicity of waste reduced, reused, or recycled
- Environmental benefits and cost savings
- Commitment of both management and line personnel to the waste reduction program
- Degree of complexity and extent of innovation shown
- Applicability of the waste reduction methods to other companies

Each winning organization is presented with a plaque and employees who contributed directly to the success of the award winning program will receive a certificate of recognition.

1992 WINNER:

Chrysler Canada Ltd., Windsor Assembly Plant, Windsor, Ontario

Awards of Merit:

Black & Decker Canada Inc., Brockville, Ontario
Court Galvanizing Limited, Guelph, Ontario

HONOURARY POLLUTION PREVENTION AWARDS*

Northern Telecom
Essex Specialty Products Inc. Canada

* presented in the Plenary Session

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PLENARY SPEAKER

TOWARDS THE WISE USE OF PLANET EARTH: THE CHALLENGE TO WORLD SOCIETY

W.S. Fyfe; President, I.U.G.S; Department of Geology, University of Western Ontario, London, Ontario, N5A 5B7

1992 saw the Earth Summit in Brazil, a clear recognition by almost all world leaders that the environment is under stress, and that new systems for development are needed urgently. Since the Industrial Revolution, human population has increased at a rate as never before in the history of *Homo sapiens*. Science and technology have developed a support system which has stimulated this vast increase. However, there has been a cost. Pollution, the waste products from our industrial systems, now threatens the most fundamental parts of life support air-soil-water and climate. The recent data from Eastern Europe clearly show the costs of inaction, of careless use of technology. In general, the world has become increasingly divided into rich and poor, those fighting for the most basic means of survival, and those who waste non-renewable resources.

We have lived through a remarkable century of scientific discovery. We discovered atoms and molecules, we discovered antibiotics, we built jet engines, nuclear power stations, and found oil and gas at sea. Then, we moved into space, and saw ourselves and our home planet for the first time. We now live in the age of observation, from the building blocks of the atomic nucleus, our genetic code, the structure of the brain, to the solar system and outer galaxies. We have a vast reservoir of knowledge and techniques.

At this time, we add almost 100 million humans to Earth each year. The human population of Earth is now over five billion, with at least double that number next century, and most of the increase will be in the so-called developing world. There will be, there must be, massive development to support these people. Can we provide the needed resources in such a way as to allow future generations to live well, without the destruction of Earth's biodiversity? Can we achieve sustainable development? There are certain basic changes needed in our technological systems. These include:

- massive increase in global energy production. At present, fossil carbon fuels dominate the energy systems. In a world of balanced opportunity, the systems would have to change. There is no shortage of energy resources on Earth. The future for most must lie in solar energy of all types (biomass, thermal, electric, wind...), and geothermal energy. We must cease the waste of energy.

- we must not allow our growing cities, the great point sources of pollution, to become environmental cancers.

- our transport distribution systems must change. For example, Canada, indeed all of North America, must modernize its rail systems, and stop wasting land resources on endless highways.

- we must protect soil from erosion, and this is possible now. We must be more careful with control of both quality and quantity in the use of fertilizers and all agri-additives.

- we must protect the quality of our air and water supplies.

- we must reduce wastes of all type and, particularly, urban wastes. For all new developments, environmental impact studies must be holistic, beginning to end, from resources to product to garbage.

- and, matching environmental impact, there must be holistic, beginning to end.

To accelerate the move to truly sustainable systems of development, a scientifically literate society is required. Perhaps, in the long run, it is only through quality education that we will achieve our objectives. Every citizen, every child, both male and female, must have a high degree of literacy, numeracy and sciency. All people must know where oxygen comes from, what happens when you burn gasoline, what happens when you flush the toilet. All people must understand the reasons for preserving biodiversity. In addition, quality education requires absolute freedom of information, and access to that information.

If we can learn to use our amazing knowledge with wisdom, the future of all humankind, our planetary experience, can be wonderful.

A1 THE ENVIRONMENTAL TECHNOLOGIES PROGRAM: GUIDE TO A SUCCESSFUL APPLICATION

Doug Vallery, Research and Technology Branch, Ontario Ministry of the Environment, Toronto, Ontario, M4V 1P5.

The development of a complete application to the Environmental Technologies Program requires considerable effort on the part of the applicant. At the same time, the review process commits considerable Ministry resources to the assessment of applications. That commitment of resources extends to partners in the program including the Ontario Ministry of Industry, Trade and Technology, and the nine provincial and federal agencies whose representatives sit on the Environmental Technologies Advisory Committee.

Adherence to the program guideline in providing the best possible proposal and information on program design and anticipated outputs and benefits is required in order that an application can succeed through the review process. It is in all parties interests that applications to the program are complete and coherent from the outset.

Applications should be submitted to address the objectives and the eligibility criteria of the Environmental Technologies Program. The ETP has been established in order to share the risk in technology development, and to support the development in Ontario of innovative environmental technologies, products and processes. The projected outcome of proposed projects must offer considerable environmental benefit to customers in Ontario, and should also offer strong commercialization potential for international markets. All projects should lead to environmental as well as economic benefits for the Province of Ontario, realized by increased employment and investment through manufacture and marketing.

Key information requirements are discussed as is the need for linkages to be developed with funding "partners". The complete application review process is described in order that prospective applicants can understand and anticipate the needs of the reviewers and program managers.

A status report on current program commitments is provided. Linkages and partnerships with other provincial, federal and international agencies are described. Current and anticipated outputs of the Environmental Technologies Program are summarized, and the need for seeking opportunities for Partnerships is highlighted.

A3 TECHNOLOGY FOR ENVIRONMENT SOLUTIONS INITIATIVE

Derek Yue; Industry, Science and Technology Canada

Technology for Environmental Solution is a $100 million, six-year Green Plan initiative designed to transfer, develop, demonstrate and commercialize environmental technologies through cooperative arrangements among the federal government, the provinces, universities, and the private sector. It is a joint Industry, Science and Technology and Environment Canada initiative, targeted at providing solutions to priority environmental problems and offering economic opportunities to Canada. This initiative has three components:

1. an $80 million Environmental Technology Commercialization Program, to provide leverage funding to accelerate the development and demonstration of commercial livable environmental technologies;
2. an $18 million Technology Transfer Program, to provide federal services to assist Canadian firms in locating, assessing, transferring, and promoting environmental technology;
3. a further expenditure of $2 million to establish an Environmental Technology Network among existing federal, provincial, and university centres of environmental technology

This initiative is to be sharply focused on priority environmental areas such as clean process technologies, waste reduction and recycling, air and water pollution prevention and control, and water conservation.

A4 PROTECTING THE PLANET'S FRAGILE OZONE LAYER. THE BLUE BOTTLE_ TECHNOLOGY DEVELOPMENT AND SUCCESS THROUGH COLLABORATION WITH GOVERNMENT.

Dusanka Filipovic and Michael D. Hirtenstein; Halozone Recycling Inc..

Halozone Recycling Inc. is a new Canadian corporation established to commercialize an invention and process for the recapture and recycling of chlorofluorocarbons, known as CFCs, and other volatile halogenated hydrocarbons such as HCFCs and HFCs.

The award winning technology, licensed from Linde Division of Union Carbide Canada Ltd., is based on a unique molecular sieve matrix, Silicalite, which selectively adsorbs CFC-type compounds. This stable adsorbent is packed into cylinders to be used commercially under the trade mark "Blue Bottle". Worldwide patent protection which covers both the use of the Silicalite molecular sieve matrix for the adsorption of CFCs and the processes for complete recovery of the adsorbed CFCs represents several years of R&D investment by Union Carbide costing more than two million dollars.
Engineers of Ontario.

The license agreement grants Halozone Recycling Inc. the exclusive rights to commercialize the process in Canada and the first right to exclusivity in all other countries except Brazil. Linde will receive a running royalty on all revenues derived from use of the patent rights beginning in 1994.

A6 RAYOX ADVANCED OXIDATION PRODUCTS

Adele Buckley, Stephen Cater and Ron Hallett; Solarchem Environmental Systems, 40 West Wilmot St., Richmond Hill, Ont. and James Bolton, University of Western Ontario, London, Ont.

Rayox(R) destroys waterborne toxic chemicals by utilizing photons from the high power Solarchem UV lamp acting with oxidizing and/or reducing agents. The original hazardous pollutant is converted to harmless components, which can be discharged readily to natural streams or public treatment works. Interested readers are invited to review the proceedings of the technical poster session for a more thorough exposition of the Rayox(R) advanced oxidation processes and their applications.

Rayox(R) is now used or being installed in over 30 sites in North America, Europe and Australia. Typical uses are in the remediation of contaminated groundwater and treatment of effluent from the chemical process industries. Examples of pollutants treated are:

- Phenols, chlorinated phenols and PAH from wood treatment
- NDMA and chlorinated hydrocarbons from chemical and textile manufacture
- BETX and MTBE from leaking gasoline storage tanks and from ballast water
- chlorinated hydrocarbons from food processing
- MEK, hydrocarbons, chlorinated hydrocarbons as steam stripper condensate -aerospace industry
- TNT, NG, EGDN from explosives manufacturing
-Hydrazine wash water from spent rocket fuel at NASA

For some of these cleanup problems, no viable alternative treatment to Rayox(R) is available, such as the NDMA in groundwater (Ontario), the contaminated ballast water (New York State), and the rocket fuel wash water (NASA at Cape Kennedy). Figure 1 illustrates the application of Rayox(R) to ballast water and shows concentration of contaminant vs. cost, i.e. dose of oxidizing material such as UV light, peroxide, proprietary additives. Note that virtually zero discharge is achievable and available with Rayox(R); the regulatory requirement at the specific site dictates the size and type of the Rayox(R) equipment and process configuration.

A7 DEMONSTRATION TESTING OF A THERMAL GAS-PHASE REDUCTION PROCESS

K. Campbell; ELI-EcoLogic International Inc., Rockwood, Ontario.

Thermal gas-phase reduction of organic hazardous waste is an alternative to incineration suitable for processing hazardous chemicals and aqueous wastes such as harbour sediments, lagoon sludges, and landfill leachates. The reaction is conducted in a hydrogen-rich reducing atmosphere at approximately 900°C and atmospheric pressure. The products of the reaction depend on the waste constituents but usually include HCl from the reduction of chlorinated organics such as polychlorinated biphenyls (PCBs) and methane and ethylene from reduction of straight-chain and aromatic hydrocarbons. The absence of free oxygen in the reactor prevents the formation of dioxin compounds

ECO LOGIC has set up a demonstration facility for processing polyaromatic hydrocarbons (PAHs) and PCB-contaminated harbour sediments in Hamilton, Ontario and has been conducting destruction tests during the spring of 1991.

The demonstration-scale reactor is 2 m in diameter and 3 m tall and is mounted on a 15 m drop-deck trailer. A scrubber system and recirculation gas heating system are also mounted on the trailer, as well as the electrical control centre. A second trailer holds a propane boiler and waste pre-heating vessel. The boiler also accepts a small portion of the scrubbed dechlorinated recirculation gas as fuel. The processing rate for the demonstration unit is 4-5 kg/min.

Results from the demonstration testing including destruction efficiencies obtained and processing costs estimates will be discussed in the paper. The complete demonstration program will consist of 15 characterization tests of short duration and longer duration performance tests.

A8A

Robert Fraser; Engine Control Systems Ltd., Newmarket, Ontario

Engine Control Systems Ltd. is marketing a CANMET-developed filter that reduces soot emissions by 90% in underground mines.

Engine Control Systems Ltd. has created an innovative filter device that removes over 50 percent of the toxic compounds and almost all carcinogens from the exhaust of underground diesel engines. For having a direct and measurable benefit to the environment, the company has been awarded winner status in the 1990 Canada Awards for Business Excellence Environment category.

Engine Control Systems manufactures catalytic converters and filters for commercial vehicles. When incorporated in 1980, the company established as its goal world leadership in pollution control devices for industrial and heavy-duty engines in closed areas. It plans to realize this ambition with innovative products like the underground exhaust filter.

Engine Control Systems supplies 80 percent of the worldwide underground mine vehicle market; and in non-mining enclosed areas, the company has gained a dominant position in North America, supplying 60 percent of the market. Overall in the available worldwide market, the company has a 50 percent share. Introduced in 1986, the soot filter reached sales of almost $750,000 in 1989.

B1 CHALLENGES FACING THE APPLICATION OF NEW REMEDIAL TECHNIQUES.

D. Major; Beak Consultants Limited, Guelph, Ontario

Increased public awareness and environmental regulations, and insistence by many financial institutions that companies assess their environmental liabilities, have increased the number of site investigations and environmental audits being done. Not surprisingly, many of these investigations and audits have uncovered organic and metal contaminants in the soil and groundwater beneath the sites. Many of these contaminants have already migrated off-site causing an increase in liability. Many current remedial technologies and approaches are ineffective, extremely long-term, and costly. This has increased demand for the development of cost-effective remedial technologies. However, development of new technologies is fraught with difficulties, which include;

- high costs and risks associated with their research, development, and demonstration;
- regulatory limitations to try new techniques or technologies; and
- lack of fundamental understanding among regulators, consultants, users and even developers, of how new technologies work and their limitations.

Government are attempting to remove these difficulties through programs such as Environment Canada's Development and Demonstration of Site Remediation Technologies (DSERT) and the Great Lakes Cleanup Fund (GLCF), Ontario Ministry of the Environment Protection Agency's Superfund Innovative Technologies Evaluation (SITE) program. One remedial technology that has great promise and has gained the attention of many regulatory agencies, users and vendors, but is also one of the most misunderstood, is bioremediation. The misunderstanding comes from the lack of awareness and oversimplification of the fundamental processes that affect microbiological activities in soil and groundwater. I will review the challenges of applying new technologies by presenting an overview of bioremediation, bioremediation case studies and discussing research needs for bioremediation.

B2 CHURCH ROOFS AND SMELTERS: CAN WE MODEL SOIL CONTAMINANT MIGRATION?

Marsha I. Sheppard and Janice L. Hawkins, Environmental Science Branch, AECL Research, Whiteshell Laboratories, Pinawa, Manitoba, Canada, ROE ILO.

Ancient churches in Denmark have been depositing soluble lead in driplines for centuries. Similarly, all over the industrialized world, smelters and automobiles have been emitting particulates containing various metals, most notably lead (Pb), arsenic (As), cadmium (Cd) and antimony (Sb). Data from long-term contamination scenarios are invaluable for testing models of soil contaminant transport. Models, reliable in reproducing long-term accumulations in surface soils, give us confidence when applied to assessments of the disposal of both nuclear and non-nuclear wastes. The SCEMR1 (Soil Chemical Exchange and Migration of Radionuclides, Version 1) soil contaminant transport model, used in Canada's Nuclear Fuel Waste Management Program, has been tested on 800 years of Pb deposition from Danish church roofs. The model was able to predict the observed accumulations of up to 11 600 mg/kg in the surface 24 cm of dripline soil. Distributions of Pb with depth can also be reproduced using SCEMR1. The redistribution of Pb following an historic addition of clean surface soil was also modelled. Predictions of surface soil Pb, As, Cd and Sb accumulations, using atmospheric dustfall data near Canadian smelters for periods of 20 years, show excellent agreement with measured soil concentrations. The SCEMR1 model has also been used to evaluate soil remediation at contaminated sites. Results show that the model can assess the long-term impact of partial removal of contaminated soil. Strategies such as additions of topsoil to bury contaminated soil can also be optimized using the model. The SCEMR1 model is particularly good at delineating the recontamination of surface soils due to the upward migration of soluble contaminants by capillary rise and evapotranspiration processes.

B3 USE OF IMAGE ANALYSIS TECHNIQUES TO DETERMINE A LNAPL SATURATION PROFILE IN A SAND MEDIUM.

P.J. Van Geel and J.F. Sykes, Department of Civil Engineering, University of Waterloo, Waterloo, Ontario, N2L 3G1

Recent literature has emphasized the need for detailed experimental work in the area of multiphase flow to verify the growing number of numerical codes used to simulate non-aqueous phase liquid (NAPL) migration in the unsaturated (air and water) subsurface. This research uses image analysis techniques to determine LNAPL saturation profiles for a two-dimensional LNAPL spill conducted in the laboratory. An experimental box, 150 cm in length, 120 cm in height and 5.08 cm in depth, was constructed with a half inch tempered plate glass front to provide visual access to the LNAPL migration. A controlled spill of n-heptane, died red with Sudan III, into a well sorted variably saturated silica sand was conducted. A series of colour slides were taken of the saturation profile with time. The LNAPL flux entering the system under constant head conditions was monitored using a data acquisition system. The slides were then digitized as black and white and rgb image files. An initial image of the experimental box and the initial lighting conditions was taken to correct for the light intensity variations across the front surface of the experimental box. Each subsequent image was registered onto the initial image and the initial image was then subtracted

from the registered image of the LNAPL plume at the time of interest. The resulting image contains the increased grey scale values due to the presence of the LNAPL plume. The relationship between grey scale and saturation was determined by equating the volume of LNAPL as indicated by summing over the image the product of grey scale values and pixel area to the known volume of LNAPL that had entered the system. It was assumed that the LNAPL was distributed uniformly across the depth of the box and that the grey scale is a linear function of saturation. The images indicate a sharp front profile with a maximum LNAPL saturation of approximately 80 percent. The remaining 20 percent is residual water and entrapped air. The value of 20 percent is in agreement with residual values found in capillary pressure - saturation experiments. The image analysis technique provides an excellent non-destructive experimental tool to determine a detailed two-dimensional saturation profile. Initial numerical results indicate the need to be able to accurately model a sharp front. Implicit one point upstream weighting techniques, which are used in most multiphase models, lead to large numerical dispersion of the front while higher order upstream weighting explicit schemes can better approximate the sharp front solution. Future work will include continued numerical modelling of the experimental results and instrumentation of the experimental box with pressure transducers. The pressure transducers will provide an additional source of data to track the movement of each phase and their corresponding pressures. The pressure transducers currently being tested are specified at +/- 0.15 percent of full scale or 2.1 mm water pressure for linearity, hysteresis and repeatability.

B4 FIELD-BASED PILOT-SCALE REMEDIATION TRIALS FOR INDUSTRIALLY CONTAMINATED ENVIRONMENTALLY HAZARDOUS SOILS

B.E. Holbein and D.W. Hall, Tallon Metal Technologies Inc., Guelph, Ontario.

The restoration of sites containing contaminated soil has become a major problem for both environmental regulatory agencies and land users/developers. Of the numerous contaminated sites in Ontario, nationally and internationally, most often, the soil contamination is attributed to historical uses of the site and can take the form of organic, inorganic or mixed contamination, with varying degrees of environmental impact.

While the MOE and other regulatory agencies have developed clean-up guidelines so as to remove or limit the environmental impact of a site and therefore permit its productive reutilization, site owners and land developers have faced high costs associated with the actual site restoration. This has impede progress in site restoration in some cases and has often delayed the development of otherwise worthwhile sites.

The lack of available technologies appropriate to site remediation can result in the more costly and less environmentally acceptable option of soil disposal at landfill. A number of technologies in development are attempting to address the treatment of organic contamination but few have addressed metal contamination or mixed, organic/inorganic contamination.

We have, over the last four years, adapted and further developed our technologies as applied elsewhere to water treatment and the mining industry, to the treatment of contaminated soil with a view to providing a soil treatment capability adaptable to mixed contamination, especially for metals and to achieving overall treatment costs competitive to transport and disposal costs. This paper provides a description of the Tallon technology, the development of a full demonstration scale plant and the results obtained in a demonstration involving the treatment of 8,000 tonnes of soil contaminated with As, Cu and Pb.

C1 THE ZEBRA MUSSEL PROGRAM -FROM COMMUNICATIONS TO CONTROLS

Judy Orendorff; Ministry of Natural Resources, Maple, Ontario.

Zebra mussels are freshwater molluscs with striped zebra-like shells. They were first discovered in Ontario in Lake St. Clair in 1988. They are believed to have arrived in 1986 in the ballast water of a freighter from a European port. Today they are found in all of the Great Lakes, the St. Lawrence, St. Clair and Niagara rivers, and small numbers of larvae have been reported in six Ontario inland lakes. Zebra mussels are spreading more quickly to inland waterbodies of the States of New York, Michigan and Illinois.

What kind of damage are they causing?

- Zebra mussels can clog water intake pipes used by municipalities, industries and power utilities drawing water from the Great Lakes (damages have been estimated as high as $5 billion over the next ten years without mitigation)
- Zebra mussels can impact Ontario's sport and commercial fishery and boating related businesses (population sizes have reached densities higher than 500,000 per square meter in Lake Erie)

A provincial committee chaired by the Ministry of Natural Resources has developed a management plan to deal with the problem of zebra mussel infestation. This committee has representation from across the Government with ongoing cooperative initiatives between MNR, the Ministry of the Environment and Ontario Hydro.

C2 USE OF ULTRAVIOLET RADIATION FOR ZEBRA MUSSEL CONTROL

D.Lewis; Aquatic Sciences Inc., St. Catharines, Ontario, and G.E. Whitby; Fischer and Porter Inc., Downsview, Ontario.

The use of chemical oxidants, particularly chlorine, has been wide spread for control of zebra mussel infestations in both the United States and Canada.

These treatments appears to have been very effective, however, there are several reasons why the search for alternate strategies continues.

The move to alternative oxidants or other potentially toxic materials does not appear to be wise in that there may arise new production, handling and short and long term environmental concerns potentially more damaging than those already understood with chlorine.

It follows that new control measures, should they be available, would focus on non chemical solutions or at least be useful in reducing chemical use.

Ultraviolet light is commonly applied in hospital and food industries for sterilization and has more recently become popular for disinfection treatment in Water Pollution Control plants as the ability to treat larger volumes of water has become available.

The investigation of UV radiation, may lead to the development of another potentially useful, readily available tool for zebra mussel control.

Preliminary results using both medium and low pressure lamps in static tests to determine mortality curves as well as a discussion of on-going field studies in flow-through systems will be discussed as they relate to veliger and juvenile mortality and prevention of downstream mussel settlement for industrial complexes.

Results with low pressure lamps (254 nm wavelength) in static tests suggest that straight mortality on contact may not be the method by which zebra mussels are controlled using UV light. Earlier tests in flow through systems using similar lamps showed that a measure of control is possible with this lamp. This indicates that the mode of control may be through bacterial or other biological control, preventing biofilm development on downstream substrates. Zebra mussels use associative chemical cues when choosing settling materials and to aid in aggregation UV may inhibit the process.

At the time of this writing, static tests with medium pressure lamps are in progress. Dose response seems to be better than with the low pressure lamp, however results are yet to be analyzed.

C3 EFFICACY AND ROLE OF ALUM IN REMOVAL OF ZEBRA MUSSEL VELIGER LARVAE FROM RAW WATER SUPPLIES.

G. L. Mackie and B. Kilgour; Mackie and Associates Water Systems Analysts Inc., 381 Elmira Road, Guelph, Ontario N1K 1H3.

There were four objectives for the present study:

(1) To determine if alum in concentrations used by water utilities and industries kills veliger larvae;

(2) To determine if alum as a coagulant interferes with some of the life processes (e.g. feeding, respiration, locomotion) that ultimately kills veliger larvae;

(3) To determine if the flocculant or the flocculation process affects the survival or settling rate (by entrapment in the floc) of veliger larvae;

(4) To verify the results obtained from the first three objectives using water samples from Ontario Water Treatment Plants.

All experiments were performed in a prefabricated laboratory on the shore of Lake Erie at Wheatley, Ontario. Although experiments are still continuing at the time of writing this abstract, the main findings are: (i) that the concentrations of alum used in most water treatment plants (i.e. 20-50 ppm) is not sufficient to kill the veliger larvae because the LC50 value is between 150 and 200 ppm; (ii) a pH depression below 4 caused by the addition of alum, especially in the mixing zone, may cause instantaneous kill of veligers; (iii) the role of alum in removal of veligers appears to be mainly a physical one, with the floc physically removing even living veligers. Most veligers remain alive for at least 24 h in the floc at concentrations below 100 ppm.

C5 LETHAL EFFECTS OF HYDROGEN ION AND ADULT ZEBRA MUSSELS, *Dreissena polymorpha*, IN RELATION TO CALCIUM CONCENTRATION OF THE SURROUNDING WATER

R.W. McCauley and E. Kott, Wilfred Laurier University, Waterloo, Ontario.

We review the literature on the distribution of *Dreissena polymorpha*, focusing on the roles that calcium and hydrogen ions seem to play as limiting and lethal factors, respectively. Also examined from this perspective are the results of laboratory investigations in which the concentrations of these ions are varied.

We collected adult zebra mussels from Lake Erie at Port Dover. The gills were excised and exposed to a series of solutions containing various concentrations of hydrogen and calcium ions. These solutions were prepared by adjusting the pH of mixtures of Lake Erie and deionized water. Concentrations of hydrogen ion at which the beating of the terminal cilia stopped were determined. Low levels of calcium ion producing similar effects on the cilia were also established. Experiments were also carried out using water of acidulated, calcium-poor lakes on the Precambrian Shield as well as a dystrophic lake in Southern Ontario.

Concentrations of hydrogen ion which were acutely lethal to gill ciliary function (exposure time: 24 h) lay in the range pH 6.3-6.8. These results indicate that half of the inland lakes of Ontario cannot support populations of zebra mussels since the median pH of these has been estimated to be 6.7.

When hydrogen ion is maintained at a non lethal concentration, i.e. 7.4, activity of gill cilia ceases below concentrations of 8 mg/L of calcium ion (4 g exposure). We speculate that the synergistic combination of low calcium and high hydrogen ion -characteristic of poorly buffered, acidified lakes - also makes these water bodies especially inhospitable to *Dreissena*.

The survival of whole adult zebra mussels in lakewaters of low pH and calcium was determined by rearing them in these waters in the laboratory. Results were in general agreement with those of the short term experiments with gill tissue, the difference being that exposure times were much longer.

D1 FACTORS CONTROLLING QUANTITATIVE SUPERCRITICAL FLUID EXTRACTION (SFE) OF ENVIRONMENTAL SAMPLES

Steven B. Hawthorne, David J. Miller, John J. Langenfeld, Mark D. Burford, Sally Eckert-Tilotta, and Peter Louie; Energy and Environmental Research Center, University of North Dakota, Grand Forks, North Dakota, USA.

Supercritical fluid extraction (SFE) can yield quantitative recovery of trace and minor analytes from solid matrices with extraction times of 10 to 60 minutes, while also reducing or eliminating the need for liquid solvents. When combined on-line with capillary GC (SFE-GC), the total time for analyte extraction, concentration, and GC analysis can be <1 hour. SFE-GC also yields excellent sensitivities from small samples since the extracted analytes can be quantitatively transferred from the extraction cell into the GC injection port. The development and application of SFE and SFE-GC techniques for the quantitative extraction and analysis of low and moderate polarity analytes (i.e., species amenable to GC analysis) from environmental samples will be presented. Factors that control SFE efficiencies, and new approaches (such as ion-pair SFE and simultaneous chemical derivatization/SFE) for the extraction of polar and ionic analytes including pesticides, surfactants, and phospholipids will also be discussed.

D2 IMPORTANT FACTORS IN ENHANCING SUPERCRITICAL FLUID EXTRACTION EFFICIENCIES FOR ENVIRONMENTAL APPLICATIONS

Joseph M. Levy; Suprex Corporation, 125 William Pitt Way, Pittsburgh, PA 15238.

Supercritical fluid extraction (SFE) has a broad range of applicability, especially with regards to environmental problems. SFE has achieved a significant amount of attention due to the benefits of eliminating toxic, liquid solvent usage, reduction in sample preparation time and an increase in the overall analytical reliability of determinations. On-line SFE/GC-MS is a powerful technique to accurately analyze and quantitate environmental analytes. In addition, the off-line transfer of SFE effluents to collection vials adds a considerable amount of flexibility in characterizing complex matrices since a full compliment of analytical tools can be used (i.e. GC, LC, IR, NMR and UV). Moreover, the advantages of SFE can be further augmented by the development of automation for greater sample throughput which can be especially important for environmental applications.

This paper will discuss the use of on-line and off-line SFE/GC-MS and FID methodologies for the determination of different target analytes in environmental matrices, such as polynuclear aromatic hydrocarbons (PAH) in soil. Details of method development will be presented

demonstrating how EPA method 8270 was followed except for the replacement of Soxhlet sample preparation with SFE. The discussion will also focus on the experimental verification of optimized SFE variables to achieve efficient and quantitative extractions of the target analytes in environmental solids. An example is shown in Table 1 where an off-line SFE/GC comparison was made between the extraction of PAHs from soil at different pressures, indicating that higher pressures were necessary for the complete recovery of the PAHs, especially the four and five ring PAHs. The use of various pre-extraction strategies (i.e. matrix manipulation, modifier addition, adsorbent use) for the enhancement of extraction efficiencies will also be outlined.

D3 CONTROL OF EXTRACTION RATES AND RECOVERIES IN SUPERCRITICAL FLUID EXTRACTION

Janusz Pawliszyn and Nick Alexandrou; Guelph-Waterloo Centre for Graduate Work in Chemistry, University of Waterloo, Waterloo, Ontario, N2L 3G1.

Initially, analytical researchers developing supercritical fluid extraction (SFE) methods used directly fundamental concepts developed by chemical engineers, which are based on analyte solubilities in supercritical fluids, to explain their results and optimize SFE conditions. However, in many instances significant discrepancy between experimental results and theory have been observed. The main reason for the disagreement is the difference in concentration levels of the compound of interest in the matrix. In engineering applications the objective is to remove a product, which is present in the raw material at levels often exceeding 1%. In this situation the effect of the matrix present in the extraction vessel is limited. Engineers are not concerned with trace amounts of product which remains adsorbed onto the matrix. Under such conditions the solubilities of the compound of interest in the fluid determine the efficiency of the overall extraction. However, target analytes are at trace levels in environmental samples, and therefore effects associated with the presence of the matrix in the extraction vessel, known to us from chromatographic experience, are becoming important. For example, partitioning of analytes between the porous surface of the matrix and the fluid and chemisorption of analytes on the active sites is expected to occur in this case. Therefore dynamics of the mass transport from the surface of the matrix to the bulk of the fluid will limit the extraction rates considering relatively high flowrates of the fluid in the extractor.

D4 SUPERCRITICAL FLUID EXTRACTION AND SOLID PHASE EXTRACTION TECHNIQUES APPLIED TO THE ANALYSIS OF PULP AND PAPER MILL EFFLUENTS FOR 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN AND 1,2,7,8/2,3,7,8-TETRACHLORODIBENZOFURAN.

Peterson, R.G., Luksemburg, W.J., Hedin, J., Silverbush, B., Werst, M., Maloney, N; Alta Analytical Laboratory, Inc., El Dorado Hills, California 95762

In the United States, the most widely applied method for the determination of 2,3,7,8-TCDD and 1,2,7,8/2,3,7,8-TCDF in pulp and paper mill effluents is NCASI 551. Sample preparation consists of separating the particulates from the water by filtration, solvent extracting each fraction separately, and combining the extracts prior to cleanup and analysis by HRGC/HRMS. This method requires the use of substantial volumes of extraction solvent. A different approach has been investigated. After filtration, the water is passed through an EMPORE C18 disk to extract the TCDD/TCDFs. Then, the particulates/filter and the EMPORE C18 disk are combined and subjected to supercritical fluid extraction using carbon dioxide (SFE-CO2). This combination of SFE and solid phase extraction (SPE) may provide a viable alternative to the use of extraction solvents for this analysis.

SS2 RESPONSIBLE CARE AT A SMALL ADHESIVES MANUFACTURER

The Headline Reads:

"Green investment, teamwork save London firm $160,000. Ideas from employees at Essex Specialty Products Inc., Canada on ways to reduce waste have helped save money and have eased the burden on the environment."

The employees at Essex are very proud to have been recognized with the Ontario Waste Management Corporation's Outstanding Waste Reduction Performance Award for 1991. "We are all very much interested in the environment. We all have children and they are going to feel the impact", said Pete Grigg, one of our plant operators.

A subsidiary of the Dow Chemical Company, Essex Specialty Products, makes urethane adhesives used to bond glass into vehicle frames. Sales to Canadian automobile manufacturers last year totalled 6 million dollars. The adhesives are sold in 45 gallon drums.

What I plan to outline here is how and why a small work force was able to design and implement equipment and procedure changes that over a 3 year period reduced liquid hazardous waste by 95% and solid waste by 60%. Annual savings of $160,000 or 2.5% of sales were generated with capital investments totalling less than $5,000.

The company program to provide more environmentally safe products will also be outlined.

SS3 ONTARIO'S POLLUTION PREVENTION INITIATIVES AND DEVELOPMENT OF A COMPREHENSIVE STRATEGY: ELIMINATING SPECIFIC CHEMICALS - DEVELOPMENT OF ONTARIO'S LISTS OF CANDIDATE SUBSTANCES FOR BANS OR PHASE-OUTS.

A.C. Socha, Risk Identification Unit, Hazardous Contaminants Branch, Ontario Ministry of the Environment, Toronto, Ontario M4V 1P5.

In June 1991 the Ontario Ministry of the Environment's Hazardous Contaminants Branch and Water Resources Branch were directed to establish a list of candidate substances to be considered for banning, phasing out or use/release reductions. The results were: (i) a process for selecting the substances, (ii) primary and secondary lists of substances for consideration, (iii) a review of the data on loadings of the primary list substances to receiving waters from industrial and municipal direct point source dischargers, (iv) a hazard evaluation of industrial and municipal effluents monitored under MISA and (v) a review of the receiving water impacts, including sediment and biota impacts, attributable to point and non-point source inputs of substances on the Primary List.

This work represents the first time that a comprehensive set of scientific criteria have been applied to evaluate a large number of environmental contaminants, resulting in priority lists of hazardous substances for banning, phasing-out (sunsetting) or reduction.

A8 "THE FINANCING OF SMALL ENVIRONMENTAL COMPANIES" SYNOPSIS

James Higgins, ETI.

Issues relating to environmental protection and pollution control are high on the public agenda. A new industry, the environmental industry has been created to respond. Initially, the industry focused on end-of pipe solutions. These will not be enough. In future, much more emphasis will have to be placed on pollution prevention, a new paradigm involving product stewardship, a multi media approach, water and energy conservation, social change, sustainable development and individual and corporate responsibility. Pollution prevention can be achieved by coordinated efforts by governments the public, the regulated industries, and a strong and vibrant environmental industry.

Two paramount problems now impede pollution prevention. These are statutory environmental liability and the souring of adequate financing for small companies in the environmental industry. This paper addresses the latter.

A10 ONTARIO'S GREEN INDUSTRY STRATEGY

George Davies; Ministry of Energy, Toronto, Ontario.

Ontario Government Recently proposed a strategy for economic renewal which focuses on green industry initiatives.

"Green Industry" refers to companies that make products, operate processes or provide services that protect or improve the environment. These companies supply the technology, and the goods and services needed for energy efficiency, water conservation, pollution prevention and the 3R's (Reduce, Re-use and Recycle).

The Green Strategy has two main objectives:

1. To increase Ontario's industrial capability to produce green products and services
2. To identify and encourage the growth of market opportunities for green products

Primary initial focus will be on the supply side of green industry - working with the Ontario Chapter of CEIA (The Canadian Environment Industry Association) to assess and enhance supply capabilities through supplier development initiatives.

Concurrent initiatives directed at demand side of green industry to assess market needs and promote market development opportunities

The ultimate goal is a self-sustaining, globally competitive green industry in Ontario.

A12 SUCCESS STORIES - SMALL ONTARIO BUSINESS ABROAD

Odette Corbu, Department of Industry, Science and Technology, Canada..

MY OBJECTIVE TODAY IS TO INTRODUCE YOU TO TWO CANADIAN COMPANIES, AGGLO RECOVERY AND BOOJUM RESEARCH AND TO PRESENT TO YOU HALOZONE RECYCLING AND HUMBER SHEET METAL "BUSINESS AT FIRST SIGHT" STORY. THESE COMPANIES ARE PART OF A LARGE NUMBER OF COMPANIES WITH WHOM I AM WORKING AND ARE SUCCESSFUL IN DOING BUSINESS INTERNATIONALLY.

THE CANADIAN GOVERNMENT CAN HELP COMPANIES TO BECOME MORE COMPETITIVE INTERNATIONALLY. THE DEPARTMENT OF INDUSTRY SCIENCE AND TECHNOLOGY CANADA (ISTC) VIA ITS PROGRAMS AND SERVICES IS ACTIVELY ASSISTING SMALL AND MEDIUM SIZED COMPANIES TO ENHANCE THEIR TECHNOLOGICAL BASE AND TO DO BETTER AND MORE BUSINESS.

ISTC HAS ITS HEADQUARTERS IN OTTAWA. IN SIMPLE TERMS ISTC -OTTAWA IS INVOLVED IN FORMULATING NATIONAL INDUSTRIAL POLICY AND IN STIMULATING INDUSTRIAL DEVELOPMENT.

ISTC HAS REGIONAL OFFICES IN ALL CANADIAN PROVINCES. I AM PART OF THE ISTC - ONTARIO REGIONAL OFFICE AND WE ARE HERE TO WORK WITH THE ONTARIO BUSINESS AND ACADEMIC COMMUNITIES.

A12A AGGLO RECOVERY INC.

Peter L. Weinwurm

COMPANY DESCRIPTION

Agglo Recovery Inc. is active in development, design, building and operating innovative recycling projects for industrial waste. The firm's technologies recycle organic and inorganic waste into reusable by-products (solvents, oils, heavy metals) and convert the residual solids to lightweight product KEYLITE by using proprietary reagent KEYMIX.

Anglo Recovery has different but interrelated technologies for recycling industrial waste. The process can be linked together in integrated train that is capable of handling a wide variety of industrial wastes.

A join venture, AGGLO/CHEM-KING, is successfully operating Agglo AFB system for recycling sludge contaminated with hydrocarbons and heavy metals.

BUSINESS OBJECTIVES

Agglo Recover Inc. is interested in identifying European companies which can utilize its recycling technologies to expand recycling services to large and small quantity waste generators.

A12B BOOJUM RESEARCH LTD.

Margarete Kalin

COMPANY DESCRIPTION

Boojum is a research and development company that focuses on the development of wastewater systems using Ecological Engineering and Biological Polishing, applied at the decommissioning of mining operations. The company was incorporated in 1984 and its annual sales are of about $1.0 million. The company employs 5 researchers.

The company has expertise in the following areas:
Ecological engineering
Biological polishing
Mining decommissioning

BUSINESS OBJECTIVES

To explore possibilities in Europe for strategic alliances with:
Geotechnical engineering companies
Organic waste producing companies
Mining companies

B5 OXIDATION OF PERCHLOROETHYLENE IN SOIL WITH POTASSIUM PERMANGANATE

G.J. Farquhar and M.J. Schnarr, Department of Civil Engineering, University of Waterloo, Waterloo, Ontario.

Aquifers contaminated with dense non-aqueous phase liquids (DNAPL's) such as chlorinated solvents pose difficult remediation problems due to the formation of discontinuous residuals within the aquifer. Several technologies have emerged to clean up such problems and most have experienced some success depending on conditions. *In-situ* treatment would be desirable in many cases provided that no additional harm is done to the aquifer.

Promising results involving *in-situ* oxidation have been obtained from laboratory scale experiments in which potassium permanganate ($KMnO_4$) was used to oxidize perchloroethylene (PCE) and trichloroethylene (TCE). Laboratory soil columns were contaminated with PCE or TCE and subsequently flushed with solutions of $KMnO_4$. Monitoring the products of PCE and TCE oxidation allowed the reaction to be followed; mass balances showed near complete removal of the pure phase residual. In most columns, concentrations of PCE in the effluent after treatment with $KMnO_4$ were less than 20u/L.

A field experiment of CFB Borden was performed to extend the in-situ oxidation process to a larger scale. It involved the clean-up of a 1.6 kg emplaced source of PCE by $KMnO_4$. Mass balances revealed a destruction of over 90% of the total PCE emplaced in a treatment time of 95 days. A system was successfully developed to treat effluent waters and reduce all contaminant concentrations to acceptable levels.

B6 *IN-SITU*/ON-SITE BIOREMEDIATION OF WOOD TREATMENT SOILS CONTAINING CHLORINATED PHENOLS AND PAHs

Alan G. Seech[1,2], Igor J. Marvan[1], and Jack T. Trevors[2] [1]Dearborn Chemical Co. Ltd. Mississauga, Ontario L5A 3T5 [2]Department of Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1

Pilot-scale field research was conducted to determine the effectiveness of organic soil amendments, controlled-release inorganic nutrients, and pure culture bacterial inoculation on bioremediation of industrial wood-treatment soils containing chlorinated phenols and polycyclic aromatic hydrocarbons (PAHs). The patent-pending bioremediation technology was based on the results of bench-scale research which indicated that wood treatment soils containing pentachlorophenol at concentrations as high as 2,200 mg/kg could be rapidly bioremediated when amended with solid-phase, specific particle size organic materials. The pilot project included in-situ treatment of soil in 27 plots, each covering an

area of approximately 10 m², and on-site treatment of excavated soils on synthetic liners. The on-site treatment cells were covered with temporary structures to allow maintenance of soil moisture within the desired range, and continuation of bioremediation through the winter. A total of approximately 300 tonnes of soil was treated. Results indicated that organic soil amendments enhanced biodegradation of PCP and PAHs and mineralization of ^{14}C-PCP. In-situ soil treated with the organic amendments supported rapid biodegradation of PCP to residual concentrations less than proposed Canadian clean-up levels for industrial soils. Excavated soil treated with an organic amendment, and inoculated with a strain of Pseudomonas resinovorans isolated on-site, also supported extensive biodegradation of PCP and PAHs. During 207 days following treatment, the soil's PCP concentration was reduced from 680 mg/kg to 6 mg/kg. Total PAH concentrations were reduced from more than 1,400 mg/kg to 35 mg/kg after 207 days of treatment. Concentrations of individual PAHs, including carcinogenic isomers (e.g. benzo(a)pyrene), were reduced to below the clean-up guidelines for industrial soils. Laboratory microcosms containing treated soil taken from one of the on-site treatment cells supported rapid mineralization of added ^{14}C-PCP, thereby verifying that the observed reduction in PCP concentration was due to biodegradation. Analysis of pore water samples collected from in-situ plots indicated that pore water concentrations of chlorinated phenols were reduced by application of the organic amendment. MicrotoxTM assays revealed reductions in soil PCP concentrations were correlated with reductions in soil toxicity. Performance data collected during this work indicate that the organic amendment technology can provide a cost effective means of remediating industrial soils containing high concentrations of chlorinated phenols and PAHs.

B7 DEMONSTRATION TESTING OF A THERMAL GAS-PHASE REDUCTION PROCESS

K. Campbell; ELI-EcoLogic International, Rockwood, Ontario

Thermal gas-phase reduction of organic hazardous waste is an alternative to incineration suitable for processing hazardous chemicals and aqueous wastes such as harbour sediments, lagoon sludges, and landfill leachates. The reaction is conducted in a hydrogen-rich reducing atmosphere at approximately 900°C and atmospheric pressure. The products of the reaction depend on the waste constituents but usually include HCl from the reduction of chlorinated organics such as polychlorinated biphenyls (PCBs) and methane and ethylene from reduction of straight-chain and aromatic hydrocarbons. The absence of free oxygen in the reactor prevents the formation of dioxin compounds. ECO LOGIC has set up a demonstration facility for processing polyaromatic hydrocarbons (PAHs) and PCB-contaminated harbour sediments in Hamilton, Ontario and has been conducting destruction tests during the spring of 1991.

The demonstration-scale reactor is 2 m in diameter and 3 m tall and is mounted on a 15 m drop-deck trailer. A scrubber system and recirculation gas heating system are also mounted on the trailer, as well as the electrical control centre. A second trailer holds a propane boiler and waste pre-heating vessel. The boiler also accepts a small portion of the scrubbed dechlorinated recirculation gas as fuel. The processing rate for the demonstration unit is 4-5 kg/min.

Results from the demonstration testing including destruction efficiencies obtained and processing costs estimates will be discussed in the paper. The complete demonstration program will consist of 15 characterization tests of short duration and longer duration performance tests.

B8 PROPOSED POLICY FOR MANAGING EXCESS SOIL & ROCK - HOW DOES IT RELATE TO SOIL REMEDIATION?

Beverley Thorpe; Hazardous Contaminants Branch Ontario Ministry of Environment

The Ministry of the Environment (MOE) is proposing changes to Regulation 309 under Part V of the Environmental Protection Act, regarding the management of wastes, in particular excess soil, rock and similar materials.

Under the Environmental Protection Act (EPA) and Regulation 309, some wastes are designated into categories; the categories are then exempted from the disposal requirements of the act and regulation. Inert fill is the category of exempted waste which is most relevant to the management of excess soil, rock and similar materials. Inert fill is defined in the regulation as "earth, rock fill or waste of a similar nature that contains no putrescible materials or soluble or decomposable chemical substances" - that is, earth, rock or waste of a similar nature that has nothing in it which will rot, such as foodstuffs, and which contains no chemical substances which are soluble or which could decompose.

The amount of excess material that actually conforms to this definition of inert fill is very limited. As a result, large quantities of materials have been managed as waste and disposed of at landfill sites approved under Part V of the Environmental Protection Act. Not all these wastes pose environmental or health risks which require this degree of control.

In addition to Regulation 309, the ministry has developed a number of guidelines concerning the management of excess materials. These guidelines have been developed predominantly for application to specific materials or in specific situations. Because they are not integrated, uniform application of the guidelines is difficult. Furthermore, there are no guidelines available for some contaminants.

As well, municipal landfill sites, particularly in the Greater Toronto Area, face severe capacity limitations. Many municipalities operating these sites have restricted or banned excavated soils. This has meant serious problems for those who need to dispose of excess soil,

for instance those in the construction sector, or utility contractors. Limiting the amount of materials which must be disposed of at these highly engineered sites would extend the operating life of the sites. Also, it is consistent with MOE goals to divert wastes from municipal landfill sites by providing for alternative disposal. And increasing the range of disposal options should help curb illegal dumping.

Finally, integration of the various guidelines would streamline the management process for rock, soil and similar materials, eliminating current inconsistencies in the procedures.

B9 PROGRESS TOWARD THE DEVELOPMENT OF A NATIONAL PROTOCOL TO ESTABLISH SOIL REMEDIATION CRITERIA.

Elizabeth Lee Hofmann; Hazardous Contaminants Branch, Ontario Ministry of the Environment, Toronto, Ontario, M4V 1P5.

The Canadian Council of Ministers of the Environment (CCME) initiated the National Contaminated Sites Remediation Program (NCSRP) in October 1989. The program was established to promote a coordinated, nationally consistent approach to the identification, assessment and remediation of contaminated sites in Canada, to provide the necessary government funds to remediate high risk "orphan" sites, and to stimulate the development of new remediation technologies. As part of this program, common assessment and remediation criteria/guidelines are being develop for use in the management of contaminated sites.

A NATIONAL FRAMEWORK FOR CONTAMINATED SITE ASSESSMENT AND REMEDIATION

Two public consultation workshops, held to review remediation approaches, identified the following key recommendations for a Canadian approach: 1) a simple classification system to identify priority contaminated sites, 2) a two-tiered approach (generic and site-specific) to develop remediation criteria, 3) accommodation for various land uses, and 4) equal emphasis placed on environmental and human health (Gaudet *et al.*, 1992). Consideration of these recommendations led to the framework shown in Figure 1. The triangular shape of Figure 1 represents the intent to focus efforts through a tiered approach. The national Classification System for Contaminated Sites allows the identification of sites of greatest risk to facilitate the allocation of resources. The generic Assessment and Remediation Environmental Quality Criteria (EQC) are used in the consistent evaluation of these sites. It is recognized that generic criteria cannot be applied directly to setting remediation endpoints for contaminated sites without due consideration of site-specific factors. Therefore, a two-tiered approach, using generic criteria as a reference point and then setting site-specific remediation objectives, was adopted. Dependent on the circumstances, the latter step may involve adoption or adaptation of existing generic criteria (criteria-based approach), or be based on ecological/human health risk assessment (risk-based approach). The framework thus takes advantage of the consistency, economy and speed of a generic approach, while maintaining some flexibility in setting site-specific objectives and the option of risk assessment when warranted. It is anticipated that a framework can be developed that delineates the scope of the criteria-based approach and the transition to risk assessment methods.

C7 PILOTING OF CYANIDE RECOVERY FOR RE-USE AT AN ONTARIO GOLD MILL: ECONOMIC FEASIBILITY FOR WIDE-SPREAD APPLICATION IN THE GOLD INDUSTRY

D.K. Kidby and J.V. McCarthy; Jasmetech Metal Technologies Inc., Guelph, Ontario.

Piloting of cyanide recovery at the CANAMAX Bell Creek Mine, Timmins, Ontario was successfully completed in October, 1991. In each of two continuous campaigns, slurry feeds of tailings and leach circuit discharge were treated at the rate of 5 tonnes of solids per day. The data obtained, supports the conclusion that it is feasible to produce a gold mill direct discharge which ins non-toxic to rainbow trout. The results also support the conclusion that, in a wide sector of the gold industry, cyanide recovery can be applied with a new positive return on investment within a payback period which is generally acceptable in the industry.

Data from other mine sites in North America will also be drawn upon to illustrate the economic feasibility of the process. The key determinants for economic feasibility are the annual cyanide usage by the mine and the unit cost of cyanide delivered to the mine. Other determinants include the life of the ore body and its mineralogy in relation to cyanide consumption. Using readily available mill data it is possible to determine the economic feasibility of applying the technology.

Where other forms of cyanide and metal pollution abatement can be replaced, the economic payback is even more favourable because of the avoidance of the relatively high costs of cyanide destruction.

C8 DECOMMISSIONING WITH ECOLOGICAL ENGINEERING

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The economic implications of the shut-down of mining operations have become an increasingly important concern, as waste rock and tailings continue to be long-term environmental liabilities. Ecological Engineering has been developed for decommissioning waste management areas of base metal, coal and uranium mines, to provide an option whereby water treatment in perpetuity may not be required.

This technology involves introducing or promoting ecosystems with inherent contaminant removal properties, within the waste management area. The developing ecosystem is assisted until it has reached a stage of self-organization, at which time, self-sustaining, water-cleansing processes are in place which require no or low maintenance. The waste management area is evaluated with respect of its potential to support natural cleansing processes. Mineralogy, hydrology, and physical layout of the site are some of the factors which determine the sequence in which Ecological Engineering processes are to be established.

Field and laboratory assessments are carried out to identify those biological processes which need to be initiated. One of these processes, biological polishing, utilizes attached algae as biological treatment systems. In alkaline water, Chara removes suspended solids, metals and radionuclides. In acid waste water, biological polishing is carried out with algae which belong to the ulotrichalean group.

Chemical changes take place in the effluents due to algal photosynthesis and contaminant/algal cell wall interactions. The field and laboratory work provide the site-specific design parameters for the Biological Polishing system. Data are generated on algal growth rates and annual contaminant removal capacities of the system. The feasibility study, then, defines those site-specific factors that determine which indigenous, attached algal populations can be developed into underwater meadows in the polishing ponds.

A second group of processes, employed by Ecological Engineering, are microbially-mediated. The removal of metals from AMD occurs through the formation of metabolic products, such as hydrogen sulphide, produced by sulphate-reducing bacteria. In sediments where the proper conditions are provided through the application of the ARUM process (Acid Reduction Using Microbiology), biomineralization takes place.

Biological processes, together with engineering, hydrology, and geochemistry of mine waste sites provide the basis for designing a decommissioning strategy. Work to date on sites where Ecological Engineering has been applied as a decommissioning technology is sufficiently encouraging that decommissioning liabilities may be significantly reduced. The potential economic and environmental benefits of Ecological Engineering may facilitate sustainable development in the mining sector.

C9 DEVELOPMENT OF A MICROCOMPUTER-BASED EXPERT SYSTEM FOR MINE/MILL EFFLUENT TREATMENT PLANT DESIGN (GOLD INDUSTRY CASE).

Abbas Zaidi, Betty Ou, and Larry Whittle; Wastewater Technology Centre operated by RockCliffe Research Management Inc., Burlington, Ontario, Canada, L7R 4L7

Process effluents generated by the gold mining industry are typically characterized by high levels of cyanide. Therefore, further treatment of the effluents is usually necessary prior to their discharge from the mine/mill site. Implementation of the most cost-effective treatment strategy, however, involves decisions requiring expertise in a variety of disciplines such as cyanide recovery/destruction processes, tailings pond design, and regulatory requirements. Currently, the relevant information is scattered in sources ranging from textbooks to government files and involves the meshing of many disciplines (cyanide speciation chemistry, reaction

kinetics, mathematical modelling, process control, separation processes, costing). Furthermore, the knowledge and insight gained by various government and industry people remains largely untapped. However, with the availability of powerful micro-computers and related software in recent years, it is now practical to build "expert systems" containing the knowledge and rules that would normally be used by the best available professionals in the field and to provide the decision makers with a tool that can process the complex information in a consistent and efficient manner. To-date, with support from the Ontario Ministry of Environment's Environmental Technology Program (ETP), the Wastewater Technology Centre has been developing a prototype expert system, METEX, for process evaluation, design and cost estimation for the gold mining industry. Currently, the system has been developed to provide conceptual design of effluent management systems for various regions in Ontario, with potential for expansion into other regions of Canada. This current prototype features a user friendly interface for decision support from the early stages of project planning to the final stages of design and costing. The user can bypass all details and use METEX only for generating the recommendations or he/she can invoke options for multi-level access to METEX's knowledge bases for review, modification and report generation of (i) process flow sheets, (ii) applicable regulatory requirements, (iii) available treatability test data, and recommended protocols for various analytical and test procedures, (iv) a definition of the jargon used in the field, (v) key references on various related topics, and (vi) preliminary design and cost estimates. The use of METEX will therefore enable decision makers in government and industry to process the complex information in a timely manner. Furthermore, METEX can be used as a tool for evaluation and selection of the most practicable and cost-effective effluent management system as well as to set appropriate regulations and guidelines for a given gold mining/milling project. This presentation will illustrate the various features of the latest METEX prototype.

D6 DIRECT SUPERCRITICAL FLUID EXTRACTION OF ORGANICS FROM WATE

Sharon E. Brewer and Peter Kruus; Centre for Analytical and Environmental Chemistry Carleton University Ottawa, Ontario.

The work that will be presented details our progress in developing a system that will extract various organic compounds from water using supercritical fluid CO_2. Our interest has been in developing a system suitable for direct SFE of contaminants for the purpose of analysis. The initial stages of this project involved determining which apparatus parameters would have the greatest e effect on mass transfer during extraction. Two extraction vessels have been constructed during the course of this project. One is suitable for 75 mL samples, and the other for 20-25 mL samples. As an example of experimental recovery, the extraction of pentachlorophenol at a spike level of 86 ppb from 20 mL distilled water samples at 200 atm, 41°C, with 30 mL of SF CO_2 gave an average recovery over three trials of 97 +/- 7%. The extraction method has been shown to be reproducible. Details of the extraction method and system, discussion of the current studies, and future work planned will be discussed in this presentation.

D7 COMBINED SUPERCRITICAL FLUID EXTRACTOR AND ION MOBILITY DETECTOR FOR SELECTED WATER ANALYSIS.

F. E. Bales, D. B. Fulton, M. W. Blaney, K.P. Naikwadi and A. R. Bossard; Pylon Electronics Inc., 147 Colonnade Road, Ottawa, Ontario, K2E 7L9.

A combined Supercritical Fluid Extractor (SFE) and Ion Mobility Detector (IMD) for selected MISA EMPL analysis is discussed. The purpose of the project is to develop a survey monitor for the conformance of waste water effluents to MISA. This involves both the development of the equipment, and initial testing of it.

The approach chosen for the configuration of the monitor is to use solid phase extraction, SPE, and selectively desorb the pollutants from the SPE material directly into the ion mobility detector, IMD, with supercritical fluid extraction. This allows for responsible chemistry analysis in the field with a potentially transportable device. The working fluid chosen is CO_2, which offers the advantages of ease of use and disposal in an environmentally responsible way. The detector chosen is the Pylon IMD, which offers excellent sensitivity. It is an analyte-selective detector which is also transportable.

D8 SAMPLING, SUPERCRITICAL FLUID EXTRACTION AND GAS CHROMATOGRAPHY/ MASS SPECTRAL ANALYSES OF INDOOR AIRBORNE CARCINOGENS.

V.M.Kanagasabapathy*, R.W.Bell, P.Yang*, L.Au*, J.Parmar*, L.Allan*, M.A.Lusis, and R.E.Chapman
Air Resources Branch, Ministry of the Environment, Weston, Ontario, M9P 3T1; * Laboratory Services Branch, Ministry of the Environment, Rexdale, Ontario, M9W 5L1.

Supercritical Fluid Extraction (SFE) is a very promising technique for environmental sample preparation because of the potential to dramatically reduce the time required for sample extraction as well as to eliminate the need for large volumes of liquid solvents such as the human carcinogen, methylene chloride. Because a multitude of control parameters are available, method optimization of this technique is difficult. Some of the variables include pressure, temperature, fluid (type and flow rate), matrix (type, moisture content and the processes occurring on its surface, viz., desorption and the mass transport onto and off surface), modifier (type, concentration and its effect on desorption and solvation), extraction vessel (geometry and orientation), restrictor type and analyte collection system.

Environmentally safe, supercritical carbon dioxide (CO_2) fluid does not have the ability to quantitatively extract polynuclear aromatic hydrocarbons (PAHs). The literature1-3 indicates that modifying the fluid might enhance the extraction efficiencies but the performance of the method is highly matrix-dependent. Moreover, the criteria for selecting an organic modifier is unclear; possibly because the nature of the analyte/matrix/ supercritical fluid interactions are poorly understood for environmental matrices3. Therefore, additional developmental work needs to be done before SFE becomes an easy-to-use, off-the-shelf method.

This report describes comparison of recoveries obtained for the extraction of PAHs from an environmental matrix, XAD-2 (styrene-divinylbenzene polymer) employing supercritical CO_2 modified with various organic solvents. The effects of duration of extraction, and fluid flow rate are also described.

A13 A VISION FOR GROUNDWATER MANAGEMENT IN ONTARIO

Sam Singer, Water Resources Branch, Ontario Ministry of the Environment.

Groundwater is one of the most precious natural resources in Ontario and it is vital to the health and economic well-being of all the people of the Province. Almost half of our municipal water systems, serving over 1.5 million people, depend on the continued availability of groundwater. Another 1.3 million people rely on private wells for their water needs.

It is estimated that there are over 500,000 water wells in the Province and some 14,000 to 22,000 more wells are being added every year. Water wells are the major sources of water for farm water supply. About 90% of Ontario farms make use of groundwater for household purposes and about 80% make use of it for livestock watering. In addition, groundwater is an important source of water for commercial and industrial operations, and for recreational purposes.

In Ontario, groundwater provides a perennial portion of streamflow throughout the year. Over most of Ontario, the mean annual contribution of groundwater to streamflow is less than 20%. However, in areas where sand and gravel deposits outcrop at the surface, groundwater contribution to streamflow can be up to 60% of the mean annual streamflow. During low flow periods, up to 100% of the flow in some streams consists of groundwater discharge.

Historically, the management of groundwater quantity in Ontario has been defined primarily in terms of regulating the withdrawal of water. In 1961, an amendment to the Ontario Water Resources Commission Act was promulgated. The amendment authorized the regulation of surface and groundwater takings. This legislation is now designated as Section 34 of the Water Resources Act. Under this legislation, most water takings in excess of 50,000 litres per day require authorization by means of a Permit to Take Water.

A14 UNIVERSITY OF WATERLOO ROTOSONIC BOREHOLE DRILLING PROGRAM. GEOLOGICAL FIELD WORK AND LAB STUDY.

G.V.R. Paloschi; Department of Earth Sciences, University of Waterloo, Waterloo, Ontario, N2L 3G1.

The Waterloo moraine west of Kitchener-Waterloo overlies several important aquifers which provide most of the drinking water for the Kitchener-Waterloo region; therefore a thorough understanding of the Quaternary stratigraphy is essential to determine the susceptibility of the groundwater to contamination. There are three main objectives in the research project: to conduct the necessary geological field work and compile the existing information necessary to understand the region's aquifers; to use historical data on land use and modern mapping techniques to indicate the region's danger spots

as far as groundwater contamination is concerned; and to suggest various alternatives in the management of groundwater quality in Ontario.

A15 HYDROGEOLOGY OF THE OAK RIDGES MORAINE

K.W.F. Howard, P. J. Smart, S. Livingstone, J. Boyce and R. Gerber; Groundwater Research Group, University of Toronto, Scarborough Campus, Scarborough, Ontario, M1C 1A4.

The Oak Ridges Moraine (ORM) is a feature of far-reaching hydrogeologic significance in southern Ontario, serving as an important groundwater recharge area and sourcing over 30 major watercourses within the Greater Toronto Area (GTA). The potential degradation of groundwater quality and the disruption of recharge areas within the ORM as a result of urban development and related activities is cause for serious concern. A problem of fundamental importance is the lack of adequate understanding of the hydrogeology of the ORM. This understanding is critical in assessing the impact of anticipated regional developments, particularly those resulting from changes in landuse and climate.

The University of Toronto Ground Water Research Group began a comprehensive regional scale geological and hydrogeological study of the Oak Ridges Moraine in 1991. The objectives of this study are the following: i) to develop a detailed hydrostratigraphy of the Oak Ridges Moraine; ii) to determine the nature of recharge/discharge conditions and the overall water balance of the moraine; and iii) to develop a two dimensional (quasi-three dimensional) groundwater flow model of the ORM aquifer system(s). It is objective iii) that forms the primary focus of this paper.

A16 IMPACT OF LIVESTOCK MANURE AND FERTILIZER APPLICATION ON NITRATE CONTAMINATION OF GROUNDWATER.

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Livestock production is a major agricultural activity in Ontario. As a result of agricultural specialization, crop and livestock production are frequently carried out as separate operations. This results in the manure generated by livestock being applied to smaller and smaller land areas. Although the fertilizer replacement value of the manure is significant, in many cases the cost of transportation outweighs the value. At this point, disposal of the manure rather than utilization becomes the objective and there is often little concern for the effects of rate, timing or method of application on nutrient availability and their use by the crop and hence environmental concerns arise.

Of particular concern is the potential impact of excessive manure application on the concentration of NO_3^- in groundwater. There are numerous isolated measurements of elevated groundwater NO_3^- concentrations in Ontario that are attributable to application of nitrogen, either as manure alone or in combination with fertilizer N and residual N from forage legume crops. The concern for NO_3^- in water arises primarily from a threat to infant health. A safe limit of 10 mg NO_3^- L^{-1} has been established for drinking water. In spite of the acknowledged potential for impact of livestock manure on water quality, only limited research has been conducted on this problem in Ontario. With the major increase in concern for NO_3^- in groundwater, it is imperative that increased effort be devoted to assessing and reducing the impacts of livestock wastes. Maximum environmentally acceptable N application rates must be defined for various nitrogen sources and soil types. These maximum rates must be based on field studies that examine nitrate movement below the root zone.

B11 PREPARATION AND USE OF A REAL-MATRIX REFERENCE MATERIAL FOR ROUND-ROBIN STUDY OF DIOXIN IN AMBIENT AIR

C. Tashiro[1], R. Clement[2], P. Steer[3], T. Dann[4] and C. Chiu[4]; [1]Wellington Laboratories, 398 Laird Road, Guelph, Ontario N1G 3X7 [2]Environment Ontario, 125 Resources Road, Rexdale, Ontario M9W 5L1 [3]Environment Ontario, 4th Floor, 880 Bay Street, Toronto, Ontario M5S 1Z8 [4]Environment Canada, 3439 River Road, Ottawa, Ontario K1A 0H3.

In 1991, an air ambient round-robin for the analysis of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) was carried out by Environment Ontario under the sponsorship of the Canadian Council of Ministers of the Environment (CCME). In order to carry out the round-robin, two reference materials were produced to represent high and low level ambient air samples. Multiple Hi-Vol samples were collected in two Ontario locations. These samples were processed to prepare bulk extracts suitable for a round-robin study. Eighteen Canadian and American labs participated in the study. Good agreement between laboratories using high resolution mass spectrometry indicated the success in preparing the round-robin reference materials.

Introduction In 1989, an ambient air round-robin for PCDD/PCDF was carried out by CCME. Laboratories were provided with real ambient air samples, ie. exposed polyurethane foam (PUF)/filter combinations. Results obtained from this small (6 lab) round-robin were highly variable. It could not be determined whether the variability arose from variations between exposed PUF/filter combinations or from lab to lab variations since a number of labs had not analyzed these types of samples before.

Over the next two years, the methodology for PCDD/PCDF in ambient air developed rapidly and more laboratories acquired HRMS capability. In 1991, a second round-robin was planned to determine laboratory capabilities. At this time, it was decided to provide the participating laboratories with ambient air sample extracts, instead of PUF/filter combinations, in order to remove a major variable in the study.

B12 PILOT STUDY FOR THE DEVELOPMENT OF A BIOLOGICAL CERTIFIED REFERENCE MATERIAL FOR ORGANOCHLORINE CONTAMINANTS.

R. Guevremont, K.W.M. Siu, P.S. Maxwell, C.A. Fraser, G.J. Gardner and S.S. Berman; Institute for Environmental Chemistry, National Research Council of Canada, Montreal Road, Ottawa, Ontario K1A 0R6.

Carp from Saginaw Bay in Lake Huron was chosen for study in this pilot project. The harvested fish was ground whole and stored at -20°C. 30 kg of tissue was further comminuted and an antioxidant (ethoxyquin) was added. Water was then added to adjust the moisture content to 85%. The slurry was homogenized and stored under nitrogen until ampouling. Each ampoule was filled with 10 mL of the homogenate. To stabilize the slurry, the ampoules were heated at 118°C for 11 minutes. The processed ampoules were then heat sealed in individual trilaminate retort pouches for ease of packaging and shipping.

To date, eight samples have been analyzed for polychlorinated biphenyls (PCBs) at regular intervals to ascertain sample homogeneity and storage stability. So far, all indications are that the material is homogeneous and stable under room temperature conditions. A few samples have also been analyzed for polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs). The results indicate that this material contains relatively high concentrations of PCBs, PCDDs and PCDFs.

B13 STANDARD REFERENCE AQUEOUS SOLUTIONS FOR HIGHLY HYDROPHOBIC MATERIALS USING THE GENERATOR APPROACH

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Standard reference materials are an integral part of the generation of high quality data. They are essential to the establishment of accuracy of the standards used to quantify target analytes and can also be used as an effective tool in the assessment of the success of the total analytical train. Many standard reference materials are available in the field of inorganic analysis and target analytes are available in a wide variety of matrices to assess methodology and to provide the laboratory with confidence in their data. The field of organics analysis in environmental samples is lagging seriously behind that of their inorganic counterparts in this area. There is a crucial need to develop new standard reference materials for use in the assessment of the accuracy of standards being used for quantification and in the assessment of method performance overall for organic analytes. The lack of such materials has arisen as a result of the low solubility of many organic compounds in water and the routine absence of many environmental contaminants in most sample matrices. Preparation of reference materials by spiking complex matrices with a target organic analyte poses a major challenge to the chemist, because of the difficulty in preparing a large, homogeneous and stable sample which is rugged enough to be used over a long period of time.

C11 ATMOSPHERIC REGION OF INFLUENCE FOR THE DEPOSITION OF POLLUTANTS TO THE GREAT LAKES

James W.S. Young and P.W. Summers; SENES Consultants, Richmond Hill, Ontario.

The term "airshed" has often been used in the air pollution context in a way that immediately conjures up an analogy with the term "watershed" commonly used in hydrology. However, no strict definition of airshed appears in meteorological or air pollution glossaries. On examining the definition of watershed, one finds that even this term has evolved from its original usage as a "divide". The divide was defined as "a line following the ridges or summits that form the exterior boundary of a watershed or river basin". From such a ridge line or divide water would shed off in two directions, hence the name watershed. The common current usage of the term watershed is to define the river basin itself as "the total area drained by a river and its tributaries" or the area enclosed by the divide.A watershed is thus fixed in space by topographical features, but there is no exact analogy in the atmosphere because air flows over hills. There are a few special cases where the atmosphere is partially constrained by a combination of local topography and meteorology (temperature inversions, local land-water breeze circulations). A good example of this is the Los Angeles basin. However, in general, the air is free to move without physical constraints.Overuse of the term airshed because of its simple connotation can be misleading and so, as an alternative, the concept of an "atmospheric region of influence" (AROI) will be explored in this talk. The concept of the "atmospheric region of influence" will be developed and its spatial pattern and direction of air mass travel explained. The distinguishing feature of an AROI is that it is time dependent.Examples of a one day AROI will be presented for sites within the Great Lakes Basin and the extension of this to a five day AROI will be shown. Finally, the atmospheric region of influence for the Great Lakes will be presented. Since the atmosphere is a major pathway for toxic chemical deposition to the Great Lakes, the AROI is a very powerful tool. The use of the AROI to explore the potential impact of widely distributed pollution sources on the Great Lakes will be introduced and some preliminary results for specific locations will be presented. The development of the AROI was one of the products of an ongoing successful partnership in pollution prevention (the International Joint Commission) that started in 1909

C12 IDENTIFICATION OF THE LOCATIONS OF TRACE ELEMENTS FOUND IN PARTICLES AND PRECIPITATION.

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During the period of Septmenber 1986 to February 1988, samples of particulate matter and precipitation collected as part of the APIOS program at Dorset were subjected to additional analyses to obtain the concentrations of trace elements. Instrumental neutron activation analysis (INAA) was used to determine Al, As, Cu, In, Mn, Sb, Se, V, and Zn. Inductively-coupled plasma-mass spectrometry (ICP-MS) was used to determine B, Al, As, Cd, Cu, Ge, In, Mn, Ni, Pb, Sb, Se, V, and Zn in the unfiltered precipitation samples. Back air-parcel trajectories were calculated at the 1000 mb level and were combined with the elemental concentrations through a Potential Source Contribution Function (PSCF) analysis as had been previously done for the major ionic species in precipitation samples (Zeng and Hopke, Atmospheric Environ 23:1499¬1509, 1989). This process provide maps of the gridded conditional probabilities that a given grid cell is a source of elevated values of the selected element observed at Dorset. The results of these analyses will be presented.

C13 EFFLUX OF TRACE GREENHOUSE GASES FROM AGRICULTURAL SITES INTO THE ATMOSPHERE.

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Trace gases have gained a prominent position among scientific topics because they cause serious economic damage to agricultural crops, damage buildings, cause health problems, destroy the ozone layer, cause smog, and they are responsible for the greenhouse effect and climate change. While agricultural productivity is affected in several ways by trace gases in the atmosphere, it can also be a source of some gases and a sink for others. The magnitude of these agricultural sources and sinks are not known accurately because no suitable measurement technology has been available in the past. Recently, new laser-based technology has been developed at the University of Guelph for the accurate, high speed measurement of the concentration and fluxes of trace gases from soil. Nitrous oxide flux measurements were made at the Elora Research Station from the end of July to mid October, 1991, using this new technology. The measurements of N_2O indicated that the fluxes into the atmosphere from bare soils are very variable. Typical emissions were in the range of 5 ng/m^2s^1, but values 10 to 100 times larger occurred for periods of a few days, because of irrigation or rainfall but not consistenly.

Application of ammonium sulphate followed by irrigation did not produce a significant increase in the flux. Application of a large source of soluble carbon (sucrose) in October 1991, caused large losses of N_2O and presumably also nitrogen (N_2) through stimulation of denitrifying microbial population. Soil cores were taken weekly from the experimental area from May to November in 1991 to study soil process-related parameters in the laboratory. Two soil microbial processes, nitrification and denitrification, were of greatest interest N inasmuch both produce some N_2O and NO. Various soil parameters important to these processes were also measured so that relationships can be developed. The N_2O in soil cores provide only periodic (weekly) estimates of N_2O gas production, compared with hourly measurements of N_2O flux with the Trace Gas Analyser. In spite of the differences in the two methods, there was generally good agreement in N_2O estimates although some discrepancies may be related to NO fluxes from the soil. The proportion of total gas denitrified (N_2 + other N gases) as N_2O ranged from about 0.05 to 0.5. Simultaneous measurements of CH_4 and N_2O fluxes from a bare soil (unfertilized), a bare soil (fertilized with manure), a blue grass and an alfalfa field have been initiated in July 1992. Preliminary results will be presented.

C14 HEALTH EFFECTS OF AIR POLLUTION ASSESSED USING ONTARIO HEALTH SURVEY DATA

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The Ontario Healthy Survey (OHS) obtained data in 1990 from more than 60,000 persons in all 42 Public Health Units (PHUs) across the Province. These data include assessments of health status, use of health care resources, socioeconomic and lifestyle measures, and nutrition and fitness information, for adults and children. In June 1988, OME implemented Air Quality Index (AQI) network, which measured air quality hourly at 34 sites across Ontario in 1989. 24 PHUs have AQI sites within their boundaries, and an estimate of ambient air exposure for these PHUs has been derived from the AQI and its components. Information from these two data sets have been combined to examine the health impact of air pollution in Ontario. At the time of writing this abstract, the Ontario Health Survey data (obtained by the Ontario Ministry of Health in conjunction with Statistics Canada) have not formally been released, and for this reason other than descriptive information cannot yet be disclosed. Assurance has been given that the data will be released by October 1992, however. A "re-release" copy of the data has been available since February of this year, and the two databases have been linked by way of geographic location, as the geographic coordinates of both monitoring sites as well as groups of respondents to the OHS are known. The data for these PHUs include information from 33606 respondents, and preliminary analysis indicated that approximately 5% of these are asthmatic. A gradient of approximately 2:1 in asthma prevalence across the 24 PHUs has been observed, and larger gradients in pollutants have also been observed. Multiple linear and logistic regression techniques have been used to determine the relative importance of air pollution and other environmental factors with respect to health outcomes, and to determine regression coefficients of the simplest explanatory models consistent with biological plausibility. This will provide the Air Resources Branch with a health effects model with which the AQI can be associated, as currently no such model exists. Further expansion of this work could lead to the development of quantitative assessment of health care utilization associated with air pollution, and ultimately to a method os assessment of air pollution costs.(Air Quality Index (components: sulphur dioxide (SO_2), soiling index (coefficient of haze, COH), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), total sulphur (TRS), 9-hour CO, air pollution index (API; combined SO_2 & COH).

D9 PREVENTION AND REDUCTION OF SOLID WASTE: WHAT DO WE NEED TO KNOW. CO-OPERATIVE APPROACHES TO WASTE REDUCTION.

Barbara Grant; Waste Reduction Office, Ontario Ministry of the Environment.

We are in the midst of a paradigm shift from an autocratic society toward a participative society. Cooperation and partnerships are more than buzz words. The increasing use of communications and general rise in literacy enables people to be aware of local issues that affect them. Equally people are more outspoken about their concerns. As a result, government and industry are changing the ways they carry out their functions. Consultation and partnerships are becoming a common, if not, the normal way of doing business. The Waste Reduction Office provides several illustrations of how the process works.

D10 THE QUANTITY AND COMPOSITION OF WASTE - DEFINING THE PROBLEM.

Virginia W. Maclaren; University of Toronto.

The development of good waste management policy in Canada can be assisted by the development of good waste management models. In turn, the development of good models is dependent on the availability of reliable waste quantity and composition data. The first part of this presentation will discuss some of the research opportunities for improving data inputs to existing waste management models. The second part of the presentation will describe different methodologies for determining waste quantity and composition data, current efforts at collecting this type of data in Canada, and key implementation issues that will have to be addressed in the collection and monitoring of such data in the future.

D10A THE QUANTITY AND COMPOSITION OF WASTE - DEFINING THE PROBLEM

Don Gorber

There are three basic methodologies which have been used to determine waste quantities and composition, each of which has advantages in certain circumstances:

•Direct Waste Analysis involves actual measurement of waste. Examples include counting or weighing trucks as they enter a landfill or waste audits and studies where samples are collected, sorted by waste type and weighed.

Materials Flow Analysis uses records of production and/or purchases to estimate the resulting waste quantities and composition. Collecting data from several sources, including adjustments for imports, exports and product lifetimes, the waste generated by consumers of products can be estimated.

Survey Analysis uses some form of questionnaire to collect data directly from waste generators. Data may be provided from records or estimated.

Typically, individual studies involve elements of each of these methodologies and some form of analytical method is required to provide a complete assessment of the waste composition. SENES has been involved with all facets of the waste composition analysis. With regard to direct analysis, SENES was involved in the Metro Toronto waste composition study undertaken as part of the SWEAP. Key elements of the study included defining sampling protocols, characterizing the waste generation sector in Metro and extrapolating the data from the limited samples to Metro-wide.

D11 REDUCTION, REUSE AND RECYCLING: WHY A HIERARCHY?

J. Hanson, Recycling Council of Ontario, Toronto, Ontario.

1. Municipal Solid Waste Composition and Management Strategies
   - Process in Design for Recovery
   - Lifecycle Analysis as a Tool for Decision Making Re: Product/Packaging Preferability

2. Municipal Solid Waste Relative to Total Waste (Incl. Class D)
   - Volumes of Class D (Resource Processing) Waste Relative to MSW (i.e. 93% to 7%)
   -Class D Wastes Relative to Products and Packaging
   - Failure of Lifecycle Analysis to Account for Environmental Impacts of Primary Resource Extraction/Usage (i.e. Quantity Pollutants Only)

3. Material Devaluation Through Recycling vs. Consistent Value Through Reuse
   - Loss of Value Added In Manufacturing and Conversion

D11A WHAT DOES THE HIERARCHY REALLY MEAN?

Drew Blackwell; Waste Reduction Office, Ontario Ministry of the Environment.

All of the 3Rs in the hierarchy effect waste reduction. Source reduction, product reuse, and material recycling all reduce waste. In fact, they do not differ very much in their effect on the waste stream: disposal tonnages change almost as effectively when materials are recycled as they do when the products they compose are used again and again or when fewer goods are produced in the first place. The significant differences between the 3Rs reside in their effects on our economic system; not on our waste stream.

To understand the different economic effects of each of the Rs, it is useful to picture recycling as the bottom line for almost all materials that enter the human

economy. The economic assumption behind that situation is that once we appropriate materials from the limited capital stock provided by the planet, we should assure that they do not leak out of our economy and back into the planet as waste. Only if they effectively replenish the planet's material stockpile (returning, for example, as compost to enrich the topsoil) should we allow materials we have appropriated to leak out of our economy.

A18 MICROBIAL TRANSPORT IN SOILS WITH AND WITHOUT MACROPORES

D. Joy, J. Abu-Ashour, J.L. Botari, C. Etches, H. Lee, C. Sopher, H.R. Whiteley and S. Zeli; School of Engineering and Department of Environmental Biology University of Guelph, Guelph, Ontario, N1G 2W1.

Environmental and public health problems associated with the spreading of sewage on land have been observed since the dawn of the 20th century. The impact of such practices on surface and ground water quality has been and still is being investigated by researchers in numerous countries. The application of liquid wastes to agricultural land can cause environmental problems even when the application procedures are within the current guidelines, as demonstrated in Ontario by Dean and Foran (1991), Fleming *et al.*, (1990) and Palmateer *et al.* (1989). A conspicuous problem found in these studies is degradation of surface receiving waters by coliform bacteria.

Many studies have shown that microorganisms can migrate significant distances in the field. It has been suggested that preferential flow through macropores, worm holes, cracks, and fractures is the main mechanism causing this migration.

The focus of our study is to investigate, using tracer bacteria and mathematical modelling, the pathways and processes that contribute to bacterial movement through saturated and unsaturated soils from application of either liquid agricultural wastes or septic tank effluents. In the first phase of this study, the suitability of using *E. coli* NAR as a tracer in these studies was investigated. Section 1 details the work which showed that *E. coli* NAR has very similar growth and survival characteristics compared to those of 3 other E. coli strains isolated from a flowing stream in Guelph. Section 2 describes studies on the migration of *E. coli* NAR through laboratory soil columns. Initial results showed that most bacteria applied to homogeneously packed and saturated soil were retained by the soil. Section 3 outlines the preparatory work on leaching bed experiments to measure migration to groundwater. To date, the facility has been prepared and tested with a chemical tracer which demonstrated the suitability of the sampling system for following bacterial migration from the bed to the groundwater.

A19 DIRECT UNDERWATER IDENTIFICATION OF GROUNDWATER DISCHARGE ZONES USING ELECTRICAL CONDUCTIVITY.

D.R. Lee; Environmental Research Branch, AECL Research, Chalk River, Ontario K0J 1J0.

A probe has been developed for mapping groundwater entry areas on the bottoms of lakes, rivers, and shallow marine environments. Groundwater flow systems are widely recognized as major sources of water and solutes

to surface waters. Although it has long been known that much of this flow enters surface waters unobtrusively through their beds (Toth, 1964; Freeze and Witherspoon, 1968 and Winter, 1976), little effort has been expended to create field methods for locating the areas of lake or river bed through which groundwaters actually enter. The geologic materials, through which groundwater moves, are notorious for their heterogeneity, spatial distribution and interconnection. As a result, the rates of groundwater discharge vary by orders of magnitude on scales of metres to tens of metres; the major inflow of groundwater may enter through relatively small and unknown areas of lake or river bed. Therefore the ability to locate zones of preferential inflow would be a major advancement for quantifying the impact of plumes of contaminated groundwater on surface waters.

B14 POLLUTION PREVENTION - A QUESTION OF DOLLARS AND SENSE?

Jack Donnan and George Zegarac; Fiscal Planning and Economic Analysis Branch, and Terrence Stopps and John Hewings; Pollution Prevention Office, Ontario Ministry of the Environment.

Pollution Prevention Defined

"Pollution" results when the release of waste residuals and contaminants into the environment causes adverse effects. Consequently, any technology or process that changes the form or reduce the concentration of pollutant discharges to the extent that no adverse effects are detected can be called "pollution prevention."

However, over the past few years, the term Pollution Prevention has taken on a more specific meaning to those involved in developing environmental protection programs and those that must comply with them. To these workers, "Pollution Prevention" has become a new paradigm for environmental protection. The term refers particularly to actions that reduce or eliminate pollutants from waste streams by means listed in Table 1.

While pollution prevention has long been recognized as an important and distinct approach to pollution control, environmental protection agencies are currently developing policies that seek to encourage or even prescribe the use of pollution prevention technologies.

B15 EMISSION TRADING FOR AIR POLLUTANTS: AN ECONOMIC INSTRUMENT TO ENCOURAGE POLLUTION PREVENTION

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Ontario and other provinces are developing regulatory programs to reduce emissions of nitrogen oxides (NO_x) and volatile organic compounds (VOCs), which are precursors of ground-level ozone. Several government ministries in Ontario, together with Environment Canada and stakeholders from industry, environmental groups and academia, have formed the Advisory Group on Emissions Trading. National Economic Research Associates (NERA), with assistance from Goodfellow Consultants and VHB-Hickling, recently completed a study for the Advisory Group. That study evaluates the issues and options involved in setting up a practical trading plan for NOX emissions from stationary sources in southern Ontario, and estimates the savings that could be achieved from using trading rather than the command-and-control standards laid out in the NO_x/ VOCs Management Plan.

B17 ACHIEVING POLLUTION PREVENTION THROUGH ENVIRONMENTAL REGULATION: THE CONSEQUENCES OF THE BILL 220/90 AMENDMENTS TO THE ENVIRONMENTAL PROTECTION ACT

G.J. Ford; Canadian Institute for Environmental Law & Policy, Toronto, Ontario.

In June 1990, the provincial government enacted Bill 220/90 amendments relating to administrative orders. The potential consequences of the amendments for a number of parties, particularly members of the business community such as secured lenders, trustees in bankruptcy and receivers will be examined. The paper will then discuss the government's need to develop policies for the implementation and enforcement of the administrative order provisions which specifically set out the scope and extend of liability of potentially responsible parties in a manner which provides them with both certainty and fairness. Based on the objectives of the Environmental Protection Act, a principled approach to imposing liability on responsible persons is proposed, followed by a discussion of and recommendations for the types of policies and legislative amendments which should be adopted. The paper concludes that, in order to achieve pollution prevention effectively, the legislation must not only be tough, it must also be clear, fair and consistently applied. And it must reflect commercial reality. The government's responsibilities for achieving pollution prevention must be balanced with those of stimulating economic activity and maintaining a sound economic base, recognizing that, at least in the short term, Canada's resource-based economy consists of a number of industries which give rise to environmental degradation.

C16 MODELLING THE INFLUENCE OF BUILDINGS AND OBSTACLES ON DENSE GAS DISPERSION

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A dispersing dense gas forms a low level cloud that is sensitive to the effects of both man-made and natural obstructions. The release of hazardous materials is unlikely to occur in the absence of some source structure, adjacent buildings, or buildings between the source and receptors of interest. In fact, nearby structures may be used as release mitigation devices. This study addresses the development of techniques for incorporating the important effects of buildings and obstacles in dense gas dispersion models.

The principal effects of structures are: to divert the cloud or plume by altering the background ambient flow and by interacting with the buoyancy influenced cloud; to enhance dilution as a result of increased levels of turbulence; and, to produce a time lag for the dispersion of the material entering the near wake of the structure.

The limited data available for studying the influence of structures on the dispersion of dense gases is frequently of a specific rather than a generic nature, and one is left to interpret, and possibly quantify, the various observations in terms of the physical mechanisms listed above.

DISTRIBUTED OBSTACLES

A typical site will consist of wide variety of sizes, shapes and distributions of buildings and obstacles. It is assumed that at least some part of the obstacles on a typical site can be represented in terms of a distributed array of homogenous roughness.

There has been considerable experimental work on dispersion in the vicinity of obstacles. The available experimental data is interpreted within the context of the integral formulation of dense gas dispersion models. This discussion addresses the principle effects incorporated in these models: advection; horizontal spreading due to negative buoyancy; and, dilution. All of these aspects of the model are presumably influenced by the presence of obstacles.

The observations for homogenous roughness can be summarized as: there is support for the view that an industrial site may be modelled as an equivalent uniform roughness; for homogeneous arrays there is little to suggest that the advection velocity should not be treated in the same manner as for smooth and small roughness surfaces; there is little evidence of any significant effect of the obstacles on the buoyancy induced spreading; the vertical entrainment correlation used in, for example GASTAR, appears to be valid for obstacle arrays; there is little to guide model development on the retention time of dense gas plumes in the wakes of individual roughness elements; and, there is no definitive data has been found, indicating typical vertical concentration profiles within the array.

Note that objective methods for characterizing the surface roughness z0 have been developed as part of this study.

ISOLATED OBSTACLES

In its full generality, the interaction of a dense gas cloud with obstacles presents a formidable modelling problem. However, individually many aspects of this problem are amenable to analysis and this approach is adopted here. Also, from a practical viewpoint, it is possible that many situations of interest can be covered by such individual analyses. This is particularly so for those interested only in a limited number of broadly similar industrial sites.

Our approach is to consider a small number of relevant and commonly occurring situations and to develop models for those cases. Within the framework of the integral model formulation we develop algorithms that will reflect the influence of obstacles on advection, entrainment and for instantaneous releases the `hold-up' near the obstacle.

The model algorithms are not intended to describe the complex flow processes near the obstacle but to quantify the net change in the cloud features as the cloud interacts with the obstacle, thereby providing a step adjustment to cloud variables at the obstacle position. This might be used to assess, for example, cloud concentrations on the front and back faces of an obstacle, but care would be required with such an interpretation. The models should retain flexibility so that updated information arising from more sophisticated models or later experiments may be easily added.

Procedures have been developed to handle several cases: two-dimensional fence (solid or porous) at an arbitrary angle to the ambient flow; a confining fence; single fences nearly parallel to the flow; two fences or buildings rows nearly parallel to the flow; single or multiple, isolated, arbitrarily shaped and oriented three-dimensional obstacles upstream or downstream of the source position.

CONCLUSIONS

The review of relevant theory and experiments demonstrates that procedures can be developed to incorporate the effect of buildings and obstacles on dense gas dispersion within the box model framework.

The dominant physical processes involved in the interaction of dense gas clouds with distributed and isolated obstacles can be specified using existing data and theory.

Preliminary results indicate that the GASTAR model correctly models the interaction of dense gas clouds with several classes of obstacles.

C17 MEASUREMENTS OF NATURAL AND ANTHROPOGENIC VOLATILE ORGANIC COMPOUNDS IN THE REGIONAL ATMOSPHERE

H. Niki, B. Khouw, Z. Wu, T. Jobson, J. Lai, D. He, E. Tumber and E. Singer; Department of Chemistry and Centre for Atmospheric Chemistry, York University

The frequent occurrence of excessive ozone concentrations remains one of the more contentious Canadian atmospheric problems, particularly in the Province of Ontario. International, national and provincial decisions on control strategies for oxidant precursors are at present in various stages of formulation. For instance, the Federal/Provincial LRTRAP (Long Range Transport of Air Pollutants) Committee is developing a management plan for dealing with Canada's O_3 problem to meet Canada's international obligations under the NOx/VOC protocol [1]. However, as described in an assessment report [2] and a research plan [3] of the CIRAC-sponsored Canadian Oxidant Research Program (CORP), there remain numerous outstanding scientific issues concerning the relative importance of anthropogenic and natural VOC emissions and NO_x vs. VOC in controlling the formation of O_3 and other oxidants in urban and rural air in Eastern North America [4]. The present project is aimed at obtaining a comprehensive database for natural and anthropogenic VOCs, both on a climatological and episodic basis, as part of the CORP activities in Ontario. For comparative purposes, distributions as well as absolute concentrations of various non-methane hydrocarbons (NMHCs) in the C2 to C10 range are being characterized at urban (York U. and downtown Toronto), rural (Dorset, Egbert, and Hastings) and remote (Fraserdale) sites in Ontario [5]. The NMHC data obtained by this group prior to the current project year has revealed the significant role of isoprene, a major known natural VOC in atmospheric chemistry, of not only these rural and remote areas but also Toronto urban sites [5]. Also, it became apparent to us that reliable information on HC distributions in the urban plume from the Toronto area is critically needed in order to better understand the Ontario rural HC data to assess the relative importance of natural and anthropogenic NMHCs for the regional oxidant formation. Research efforts during the current project period has been focused on the characterization of (1) climatological (seasonal) features of ambient concentrations, isoprene and other NMHCs at a remote forested site (Fraserdale), (2) 1992 summer intensive study at Hastings, a rural site occasionally impacted by the Toronto urban plume, and (3) comparison of NMHC distributions at Toronto urban/suburban sites (Bay Street and York U) and in congested traffic (Windsor Tunnel and Highway 401). Data analysis for (2) has not yet been completed; thus, highlighted in this paper are some of the key findings from (1) and (3).

A21 METAL ENHANCED DEGRADATION OF HALOGENATED ORGANIC COMPOUNDS

S.F. O'Hannesin and R.W. Gillham; Waterloo Centre for Groundwater Research, University of Waterloo, Waterloo, Ontario N2L 3G1.

Remediation of contaminated groundwater has become a very important technical challenge. Existing technologies are generally costly, and are marginally effective in many situations. This paper presents a new innovative technology that has the potential to be a cost-effective method of remediating groundwater contaminated by halogenated organic compounds.

Experimental evidence from both batch and column laboratory tests indicates that certain metals are highly effective in enhancing the degradation of halogenated organic compounds in aqueous solution. Half lives for a range of halogenated methanes, ethanes and ethenes ranged from a few minutes for carbon tetrachloride (CT) to a few hours for tetrachloroethene (PCE).

Two applications of this technology are being developed. The first concerns the construction of a permeable wall containing a metal mixed with sand, placed within a contaminated aquifer. Where applicable, this method could prove to be an entirely passive and cost-effective means of aquifer remediation. The second application concerns the use of the metal in an above-ground treatment facility. Treatment canisters are being designed that should have a much longer service life than activated-carbon canisters and should not require regeneration or disposal at toxic waste disposal sites. Small-scale field tests of both applications are in progress.

A22 DEVELOPMENT OF SEALABLE-JOINT SHEET PILE CUTOFF WALLS FOR GROUNDWATER REMEDIATION.

R.C. Starr, J.A. Cherry, E.S. Vales, D.J.A. Smyth, and R.J. Jowett; Waterloo Centre for Groundwater Research, University of Waterloo, Waterloo, Ontario, N2L 3G1.

Low hydraulic conductivity cutoff walls are used in subsurface remediation for minimizing the migration of contaminated groundwater plumes, improving the effectiveness of pump-and-treat systems, isolating groundwater contaminant source zones, and isolating subsurface regions for in situ treatment. A new type of cutoff wall that consists of steel sheet piling with joints that are sealed after driving has been developed at the University of Waterloo. Sealable joint sheet piling overcomes many limitations of conventional cutoff wall construction methods for subsurface pollution control. Joint configurations with external and internal sealable cavities have been developed. More than 15 experimental cutoff walls have been built using external cavity sealable joint sheet piling. The tooling required for manufacturing sheet piling with an internal sealable cavity at each joint has been acquired, and an initial batch of sealable joint sheet piling has been produced. Internal sealable cavity sheet piling was used for constructing a test cell to a depth of 15 metres at Canadian Forces Base Borden. A hydraulic test of the test cell indicates that the hydraulic conductivity of the sealable joint sheet pile cutoff wall is less than 10-8 cm/s, which is low enough for many environmental applications. Laboratory and field evaluations of additional joint sealants are underway.

Sealable joint sheet piling will be marketed in conjunction with corporate partners as a comprehensive system, the Waterloo Barrier, consisting of sealable joint sheet piling (patent pending), driving, joint sealing, and construction inspection. The Waterloo Barrier has passed all of the prototype field testing necessary for the technology to be used at industrial and waste disposal sites. Use of the technology is presently being considered by several industrial organizations and government agencies.

Sealable joint sheet pile cutoff walls may be used at many sites with contaminated groundwater in industrialized areas throughout the world.

B18 ENVIRONMENTAL RESTRUCTURING OF THE ONTARIO ECONOMY.

Bill Empey, ARA Consulting, and Sharon Bailey, Ontario Ministry of the Environment

International trade, recession, domestic economic policy are among the factors that are contributing to the current restructuring of Ontario's economy. The impact of this restructuring on Ontario's environment is not known. However, it is possible that a decline in primary industries and basic manufacturing and an increase in service sector industries may lead to an improvement in environmental quality. This shift in industrial composition has important environmental implications.

In September 1992, the Ontario Round Table on Environment and Economic released its report "Restructuring for Sustainability" which outlines four key strategic directions for moving Ontario towards sustainability including the greening of the economy by integrating environment and economic factors in decision making.

Building environmental sustainability into economic decisions is the first priority of pollution prevention. Pollution prevention emphasizes source control over end of pipe technologies. Since economic activity is a major source of pollution, the concept of pollution prevention implies that economic activity must itself be changed to minimize its adverse environmental impact. Certainly if restructuring reduces waste or promotes the efficient use of resources it will promote sustainable development. This interaction between economic restructuring and the environment is called environmental restructuring and this idea can be explored in two different ways:

- by examining new information systems and associated government policies and individual and business decisions that seek to shift economic development towards the sustainable use of resource; and
- by examining the extent to which structural change (which is already occuring in the economy) is shifting economic development towards the sustainable use of resources.

B19 CAPITAL INVESTMENT CYCLES AND ENVIRONMENTAL PROTECTION

Avery Shenfield, Ernst & Young, Toronto, Ontario

There are four ways in which the timing of environmental protection investments can alter their impact on a firm's competitiveness:

1. In many cases, environmental protection equipment or processes are most cost-effectively installed at the same time as a major expansion or upgrading of the firm's production processes, rather than as a retrofit in an existing plant;
2. Retained earnings are often less costly than external capital. This suggests that advantages exist to having environmental protection process and equipment spending coincide with a period in which earnings are high relative to the firm's other investment capital needs;
3. Where external capital is used, the firm could face higher environmental capital financing costs in periods in which it is already undertaking other, non-environmental capital projects;
4. The present value of any environmental protection costs will be lower the further into the future such costs are incurred. This provides a motivation for firms to seek to delay such costs.

Note that these four forces will in some cases operate in opposing directions over the course of the business cycle. Thus, it is important to understand, from the perspective of Ontario businesses, which of these effects are the most dominant ones.

B20 POLLUTION PREVENTION, WHAT DOES IT MEAN FOR THE ONTARIO ENVIRONMENTAL PROTECTION INDUSTRY?

Avery Shenfeld; Ernst & Young, and George Zegara and Rohan Gaghadar; Ontario Ministry of the Environment.

The Ontario Ministry of the Environment has emphasized the prevention of pollution at its source, rather than end-of-pipe controls. This includes the use of process modifications, closed loop processes, substitute raw materials and product redesign to reduce or eliminate waste bi-products. This could actually reduce future demand for some segments of the environmental protection industry that are linked to the supply of end-of-pipe equipment.

In a September 1991 press release, the New Directions Group, a committee consisting of industry, academia, environmental groups and other non-government organizations emphasized that "Minimizing the generation of pollution must be given priority over controlling discharges by end-of-pipe treatment."

Specific industries in Ontario are also adopting the principle of pollution prevention. On May 29, 1992, the Honourable Ruth Grier, Ontario Minister of the Environment, announced a Memorandum of Understanding (MOU) with Chrysler, Ford and General Motors, - the "Big Three" Ontario automakers. The MOU set a precedent by making the Ontario automaking industry the first industrial sector to voluntarily introduce a program aimed at pollution prevention. The MOU targets persistent toxic chemicals, encourages pollution prevention within all sectors of the auto industry and adopts a multi-media approach to environmental management.

This paper looks at the recent growth of the Ontario environmental protection industry, examines the trends and outlook for its markets and assesses how pollution prevention may change the direction of the industry in the future. Attention will be paid to how pollution prevention may affect the industry in terms of structure, size, players and end products and services.

B21 THREE BATTLE FRONTS IN THE WAR ON WASTES: PAYING FOR WASTE REDUCTION AND RECYCLING.

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Three battle fronts exact payment for waste reduction and recycling programs in the war on wastes. "Advanced Disposal Fees" are levied at the production stage, "Deposit Programs" are levied at the time of purchase and "User Fees" are paid when wastes are disposed. The mix and magnitude of waste reduction and recycling program fees affects consumer purchase choices and so impacts manufacturers and distributors.

An advanced disposal fee is intended to achieve source reduction of wastes. A fee, based on the disposal cost of the selected materials or products, is levied on manufacturers that use these items. For example a fee on packaging materials provides an incentive to use less packaging, resulting in less waste.

A deposit program provides a financial incentive to consumers to recycle certain wastes, such as used beverage containers or lead/acid batteries. A deposit is paid by the consumer at the time of purchase and is recovered when the used product is returned for recycling or proper disposal.

Waste generators are assessed user fees to pay for waste collection, transfer, recycling, and disposal. Recently, governments have started to design user fee structures to promote waste reduction and recycling. User fees have been levied on commercial and industrial wastes for some time and are increasingly implementing user fees for residential wastes as well.

BP22 AN ASSESSMENT OF THE SOCIO-ECONOMIC IMPACTS OF SOLID WASTE MANAGEMENT OPTIONS IN ONTARIO

Murray Trott; VHB-Hickling, Atif Kubursi and David Butterfield; Econometric Research Limited and McMaster University, and Orna Salamon; Ontario Ministry of the Environment

The growing economic prosperity of Ontario in the 1980's was accompanied by increases in the generation of solid waste requiring disposal. At the same time, landfill and incineration capacity in the province has not kept pace and the difficulty of finding acceptable new sites underscored the importance of alternatives to the traditional means of solid waste disposal. In March 1989, the Minister of the Environment announced targets to divert 25 per cent of residential and commercial-industrial-institutional (IC&I) solid waste by 1992, and 50 per cent by the year 2000. In recognition of the need for more comprehensive information on solid waste generation, the 3Rs and the effects of different policy measures on solid waste generation and diversion the Ontario Ministry of the Environment contracted VHB Research and Consulting Inc. (VHB) and Econometric Research Limited (ERL) to assess the costs, benefits and consequences of various solid waste management policy options on the Province.

The major objectives of the study are as follows: 1) to define illustrative waste diversion scenarios which achieve the provincial solid waste diversion targets and 2) to provide estimates of the economic impacts and consequences of these scenarios.

C20 THE ANALYSIS OF LEAD IN SOILS BY ELECTROTHERMAL VAPORIZATION-INDUCTIVELY COUPLED PLASMA ATOMIC EMISSION SPECTROMETRY.

Cameron Skinner and Eric D. Salin; Department of Chemistry, McGill University, Montreal, P.Q., H3A 2K6.

As part of our general study of techniques and methodologies for the direct analysis of solid samples we have studied lead in soil. Lead is one of the most common toxic metallic polluters due to its use in a variety of industries. We are particularly interested in techniques which allow a rapid survey of a material to determine approximate concentrations. Most of the toxic metals are low boiling and consequently should be suitable for vaporization directly from raw soil without digestion. We have used a modified furnace (described previously) to determine lead in soil from a former battery plant site in St. Jean, Quebec, as well as soil standards. Detection limits for the technique seem to be at the natural urban level. The sample must be dried and slurried in water, however no digestion or additional reagents are needed. The technique itself will be discussed as well as the data from the site, which was heavily contaminated.

C21 DETERMINATION OF HYDRIDE-FORMING ELEMENTS: PAST, PRESENT, AND FUTURE

Ian D. Brindle; Chemistry Department, Brock University,St Catharines, Ontario L2S 3A1.

"Arsenic is ubiquitous. Every particle of coal dust or ashes, every tin-tack and every cooking vessel, is slightly arsenical. Few manufactured food materials or food ingredients are entirely free of it. The glass of white bottles contains it and gives it up to some of the substances stored in them, whence it also enters into food. The Royal Comission on Arsenical Poisoning, recognizing this ubiquity, limited the permissible quantity to 1/100 grain per pound in solid and 1/100 grain per gallon in liquid foods."

Thus, standards of 0.7 ppm for solid and 70 ppb for liquid was introduced near the turn of the century for foodstuffs. Arsenic, as a poison, had been known for centuries. The first recorded arsenic poisoner was Lacusta who, according to Suetonius' "History of the Twelve Caesars", provided arsenic to Agrippina to poison Claudius, and to Nero, who used it to poison Agrippina's son Brittanicus.

C22 INSTRUMENTATION FOR RAPID ANALYSIS OF TOXIC ELEMENTS BY INDUCTIVELY COUPLED PLASMA SPECTROMETRY

V. Karanassios; University of Waterloo, Department of Chemistry, Waterloo Ontario N2L 3G1

The ideal sample preparation method for the analysis of trace elements is rapid, solventless, inexpensive and automated. Rapid and solventless sample preparation means that liquid and solid samples must be analyzed without an acid digestion step and with minimum pretreatment (e.g., dilution, grinding). By eliminating the time-consuming, cost-ineffective and difficult-to-automate acid digestion step, sample throughput is increased, cost is reduced and personnel is not exposed to potentially hazardous digestion reagents. Also, "completeness" of digestion and analyte loss for volatile elements are no longer a problem. Of the various alternatives, direct sample insertion (DSI) devices and electrothermal vaporization (ETV) devices closely approach the ideal described above. In DSI-ICP, a sample is placed into or onto a probe (e.g., a graphite cup) with subsequent insertion of the sample carrying cup into the plasma. However, because the ICP is used for vaporization, atomization and excitation, ICP and DSI parameters cannot be optimized independently. In ETV-ICP, a sample is electrically heated and vapors so generated (e.g., atoms, ions, molecules, aggregates) are carried into the ICP for further atomization and excitation/ionization. Although vaporization (in the ETV device) and excitation (in the ICP) can be optimized independently when using the system, "vapor transfer problems" (e.g., vapor-transport, vapor-dilution and vapor-condensation onto the inner walls of the tube) limit the acceptance and applicability of this system. Clearly, a sample introduction system that combines both DSI and ETV concepts is desirable.

D15 THE FIRST STEP IN POLLUTION PREVENTION: QUANTIFYING AND CHARACTERIZING CANADIAN HAZARDOUS WASTES.

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Canada, on a per capita basis, is one of the largest generators of hazardous wastes in the world. It is estimated that Canadians produce 8 million tonnes of hazardous waste per year, of which only 40 % are treated. The remainder of this waste is sent to landfill or to municipal sewers. A goal of the federal government's Green Plan is to reduce the generation of wastes in Canada by 50 % by the year 2000, largely through pollution prevention. In order to identify the major generators of hazardous waste in Canada and the most significant waste types being generated, Environment Canada contracted with Apogee to design a methodology for establishing an annual Canadian hazardous waste inventory and characterization study (CHWI). The purpose of the inventory will be to: prioritize target sectors (generators and waste types) for waste minimization and pollution prevention initiatives; monitor achievements in waste reduction, re-use and recycling; and fulfil Canada's commitment to produce an annual report to OECD in accordance with the Basel Convention. (The methodology study was split into two distinct phases. Phase I first evaluated previous inventories undertaken in Canada for their potential data contributions to the CHWI. Due to conflicting definitions of hazardous waste, the fact that most of the inventories are approximately a decade old, and the highly aggregated level in which most of the data were reported the majority of past inventories were of little use to the CHWI. The remainder of Phase I work recommended the options to be used for the following key components of establishing the CHWI; the definition of hazardous waste;-the hazardous waste classification; the industry classification system; the estimation methodology; and the methodology for measuring the results of pollution prevention initiatives. A detailed workplan for completing the CHWI was prepared in Phase II. The workplan illustrates how to prepare the baseline database, the data sources, and the data manipulations required. The primary source of hazardous waste generation data recommended to be used was the Ontario Generator Registration Database. The workplan then outlines the approach to be used for determining waste reduction achievements between the baseline and subsequent years in which the inventory is prepared. A database to house the CHWI was also designed as part of the Phase II work. The database will be run on a IBM-PC compatible computer.

D16 DEVELOPMENT OF MERCURY_FREE REUSABLE ALKALINE MANGANESE DIOXIDE ZINC CONSUMER BATTERIES.

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At the present time small format batteries represent a US $11 billion business worldwide. Consequently billions of small format batteries are discarded every year. Hazardous chemicals such as lead, cadmium and mercury end up being deposited in landfill sites and are potentially introduced into the groundwater or released into the atmosphere when waste containing batteries is incinerated. The Canadian Standards Association reports that approximately 13 metric tons of mercury are disposed of annually into our Canadian environment. Since 1987 Battery Technologies Inc. (BTI) has innovated the reusable alkaline manganese dioxide (RAM)-zinc technology for applications in the consumer market. With assistance from the Ministry of the Environment BTI is developing mercury free AA rechargeable alkaline cells. The environmental benefits of the project are the elimination of mercury from household batteries and hence the reduction of hazardous battery waste and furthermore the reuse of valuable raw materials by rendering traditional alkaline household batteries rechargeable. Depending on the use conditions BTI has demonstrated that one AA RAM cell is capable of replacing between 7 and 20 primary alkaline cells and between 20 and 50 zinc carbon cells. Detailed information on applications for this new technology as well as electrical performance, shelf life data and battery waste related issues will be provided. The project once commercialized is expected to greatly contribute to reducing the waste management problems associated with the disposal and incineration of household batteries

D17 RECYCLING OF PRINTER'S INK: APPLIED TECHNOLOGY PROVIDES POSITIVE ENVIRONMENTAL IMPACT.

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Environmentally responsible does not have to mean fiscally costly. In our business community there is an unfortunate perception that environmental issues are costly, political and to be avoided. The words 'environment' and 'liability' are unfortunately seen as tied together.

This emphasizes the negative and fails to consider that the most efficient use of our scarce resources occurs when business chooses those alternatives which balance the cost/benefit equation. The trick is to ensure that all costs and all benefits are included in this equation. These costs must include environmental costs.

Too many of us are quite willing to pollute our water as long as we are upstream. We all want to read our

newspapers but hesitate to have a landfill site next door. Government regulation attempts to ensure that business and consumers are not allowed to benefit from their consumption while passing the cost on to another party. Unfortunately, regulation by its nature is restrictive and preventative rather than proactive. We are prevented from one course of action as opposed to encouraged to take another.

We are currently developing a printer's ink recycling system which emphasizes two environmentally positive characteristics. It encourages closed loop recycling and it is placed extremely close to the beginning of the consumption cycle, on the manufacturers floor. It also deals with waste printer's ink; a liquid hazardous waste which poses a most difficult disposal problem. Every drum kept out of landfill is an environmental victory.

D18 DEVELOPMENT OF A NOVEL PROCEDURE TO DISINFECT BIOMEDICAL WASTE.

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A new mechanical/disinfection system is being investigated as a method of treating biomedical waste. The system consists of a Bio-Nurbel 100 machine that grinds the waste and simultaneoulsy disinfects it with a novel disinfectant VSBF. VSBF is a virucidal, sporicidal, bactericidal, and fungicidal agent. Its action is due to the liberation of oxygen from potassium monoperoxysulfate. The addition of two non-hazardous organic acids, malic and sulfamic, insures a longer-lasting oxygen release, and a non-ionic surfactant enhances penetration of the cell wall. VSBF efficacy testing was performed by mixing equal volumes of microbial culture and VSBF solution in flasks for contact periods of 1, 10, and 60 minutes. Other experiments, conducted in the Bio-Nurbel machine, incorporated microbial cultures mixed with the waste before processing. The densities of microorganisms used for testing were $>10^7$ organisms/mL, equivalent to the maximum level of contamination likely to be found in water and wastewater. Sodium thiosulfate was used to neutralize VSBF, and all tests were performed in triplicate. The organisms were enumerated using spread plate and MPN techniques for bacteria and yeasts, plaque assay for MS-2 phage, and TCID50 titration for viruses. The results of the flask suspension tests showed that 100% inactivation of poliovirus type 1 could be achieved following exposure to 0.5% VSBF for 10 min. Complete inhibition of adenovirus type 2 was noted after 10 min. using a 2% solution of VSBF. Exposure to 5% VSBF for 60 min. produced kills ranging from 100% for yeast, MS-2 phage, and nonsporforming bacteria to 99.999764% for sporeforming *Bacillus cereus*. The inoculated, organic containing biomedical waste processed in the Bio-Nurbel machine required VSBF concentrations of 5% or more to produce complete inhibition of the test organisms. In summary, VSBF is as effective as chlorine but it has the advantage that it will not produce potentially hazardous byproducts.

AP1 DESIGN, EVALUATION AND MARKETING OF A MODULAR DRINKING WATER PILOT PLANT FOR THE 1990's

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The drinking water treatment industry in Ontario is currently faced with a period of unprecedented challenge. The identification of new contaminants, emerging regulations and heightened public awareness of water quality have all contributed to this situation.

To meet this challenge the industry requires new responses. Alternative treatment technologies such as ozonation and granular activated carbon (GAC) adsorption must be investigated. Because these technologies represent a significant departure from current practice they will require much more thorough investigation than has been traditionally associated with treatment plant upgrading. Since many utilities will be facing this situation there is an urgent need and a potentially substantial market for a tested modular drinking water treatment pilot plant design which could be marketed in Ontario and elsewhere.

The University of Waterloo has designed and fabricated and is in the process of testing such a modular pilot plant with funding and associated support from the Ontario Ministry of the Environment (Environmental Technologies Program and Drinking Water Section, Water Resources Branch), the Brantford Public Utilities Commission, the Regional Municipality of Ottawa-Carleton and the Windsor Utilities Commission. Aside from the development of a modular pilot plant which will be marketed commercially (anticipating mid-1993), the study will also provide valuable data, particularly with respect to ozonation, for possible process modifications at the above municipalities (each representing a different type of surface water found in Ontario).

The pilot plants are constructed only of stainless steel, glass and inert fluorocarbons. These materials are also used for sealing purposes and in all pumps, piping, mixers, tanks, columns and water contacting surfaces of instrumentation associated with the plants. This has been done to eliminate organic contamination which can be associated with other construction materials.

The pilot plants are "modular" in that any of the units within the treatment configuration can be added, have flow redirected to or removed to test different process sequences with relatively little difficulty. Unit processes include: presedimentation tanks, in-line/static mixers, flocculation tanks, sedimentation tanks, settled water storage tanks, ozone contactors, ozone dissipation chambers, filters, filter adsorbers (GAC/sand), GAC contactors, backwash water storage tanks and pumping wells (where height restrictions prevent gravity flow). All glass columns can be relatively easily modified to serve as either ozone contactors, ozone dissipation chambers, filters or GAC contacters. Upflow flocculation units and flotation tanks may be considered in the future. Disinfectants/oxidants such as chlorine, chloramines, potassium permanganate, ozone and hydrogen peroxide/ozone (PEROXONE) are being investigated. Provisions for the application of other disinfectants (such as chlorine dioxide) has been provided for. All plants have computer assisted process and instrumentation control and on-line data collection and storage.

On-line parameters which are being monitored in the current phase of study include: temperature, pH, turbidity, flow, chlorine residuals, ozone in gas to contactors, ozone in gas from the contacters and dissipation chambers and ozone in ambient air. Differential pressure in the dual media filters and filter adsorbers is also measured on-line. Off-line parameters include: total hardness, calcium, alkalinity, disinfectant residuals, UV absorbence, colour, total organic carbon (TOC), trihalomethanes (THMS) and trihalomethane formation potential (THMFP), chlorine demand, coliforms and heterotrophic plate count (HPC) organisms.

Other parameters being considered include: major ions, heavy metals, nitrogen compounds, phosphorus, threshold odour number (TON), total organic halides (TOX) and total organic halide formation potential (TOXFP), ozonation byproducts (e.g. formaldehyde), other chlorination byproducts, assimilable organic carbon (AOC), specific organics (volatile and extractable), Giardia and additional odour monitoring (flavour profile analysis and chromatographic sniffing).

BP1 DEVELOPMENT OF MEMBRANE TECHNOLOGY FOR DRINKING WATER PRODUCTION: TREATMENT OF COLOURED SURFACE WATERS

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Surface drinking water supplied in northern Ontario are often characterised by small flow rates, low temperature and high colour. These waters also more easily form disinfection byproducts (DBP) when chlorinated.

This paper briefly reviews conventional pilot plant technology based on coagulation, sedimentation and filtration, but it is focused on a new membrane technology, low-pressure reverse osmosis or nanofiltration, suitable for the removal of colour and DBP precursors from surface water. Membrane processes have the following recognised benefits, when compared to conventional methods: i) treatment without the addition of chemicals or the generation of sludge, ii) superior finished water quality and iii) simplicity of operation. Zenon has developed two nanofiltration membranes with molecular weight cut off of 500 and 4000, especially designed for the treatment of coloured water. The membranes are housed in a unique transverse flow

module that provides excellent performance while requiring minimal pretreatment when used to treat surface water.

Over the last two years, Zenon's nanofiltration membranes have been extensively tested in-house and in the field to study performance on several types of water and to optimise operating conditions. Sites of pilot studies include: Prince Rupert in British Columbia, Ottawa and Caramat in Ontario, Sept-Iles, Rawdon and Deux-Montagnes in Quebec, as well as two sites in Northern California. The evaluation studies have been conducted in collaboration with independent organizations: Transport Canada, American Water Works Association (AWWA), the Ontario Ministry of the Environment and the Quebec Ministere de L'Environment.

This paper will focus on water quality: removal of turbidity, pathogens, colour, total organic carbon, and DBP precursors. Typical operating results and projected capital and operating costs will also be presented.

AP2 ENHANCED OXIDATION AND REDUCTION TECHNOLOGIES FOR TREATMENT OF CONTAMINATED WATER

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During the ETP sponsored research and development program, there have been extensive product and process improvements of the Rayox(R) Enhanced Oxidation Product. This paper focusses on process improvements that have resulted during the course of this project.

Photodegradation of pollutants have almost exclusively been based on processes involving oxidative reactions (called Enhanced Oxidation Processes) initiated by very reactive radicals, such as hydroxyl radicals (•OH). Hydroxyl radicals are usually generated by the photolysis of hydrogen peroxide or ozone. The hydroxyl radical attacks organic pollutants and initiates a cascade of oxidative reactions leading to mineralization of the organic pollutants. The enhanced oxidation processes have had good success in the treatment of waters containing pollutants such as aromatic and olefinic compounds. The technology has also been applied to the reduction of GOD and TOC. Typical water types represented in the 35 full-scale Rayox(R) field installations include groundwater, industrial wastewater, and steam condensate from activated carbon. New applications being explored include landfill leachate and drinking water treatment.

While enhanced oxidation can be successfully applied to the destruction of many pollutants, there are a number of more refractory substances (e.g., haloalkanes and certain aliphatic ketones) that degrade slowly under these oxidative conditions. We have developed a photodegradation process (Rayox(R)), based on the use of reducing agents, that destroys and effectively detoxifies haloalkane pollutants in waste streams. We have demonstrated the effectiveness of this process for polluted ground waters, as well as synthetic mixtures of haloalkanes. Improvements in destruction rates range from four-fold to ten-fold or higher depending on the application. For waters that contain a mixture of easily oxidized pollutants (aromatics, olefins, etc.) and more refractory haloalkanes, a combination of oxidation and reduction offers the most economical treatment approach.

In summary, most applications of Rayox(R) have employed enhanced oxidation for the treatment of contaminated waters. For wastewaters containing refractory haloalkane pollutants a new photodegradation process, based on the use of reducing agents, is effective for the treatment of these waste streams. When combined with a more traditional UV/peroxide treatment, degradation of all organic pollutants is possible in a cost-effective manner.

BP2 HARD METAL, HIGH EFFICIENCY SLUDGE HANDLING PUMP

J.C. Hayward; Hayward Gordon Ltd.

The proposed pump design offers a superior solution to the transfer of heavy municipal and industrial waste sludge. Through the further development of existing screw centrifugal pump technology and manufacturing methods, both operating and capital costs for sludge handling will be reduced.

The new design plus the use of special machining methods will allow wider use of abrasion resistant hard metals in the wearing areas of the pump. This will provide longer life for wet-end parts and reduce maintenance costs.

Construction of high efficiency screw impeller pumps utilizing "super hard" metals will allow them to be used in applications ow using much less energy efficient designs such as vortex pumps. This will result in lower capital costs from the use of smaller motors and lower energy consumption due to the higher efficiency.

The project is well underway - three prototypes have been built, tested, and further modified. Some orders have already been received for these pumps in Canada and the United States. Eight additional prototype models are planned including hydraulic designs featuring low head/high flow characteristics commonly found in waste water treatment plants.

AP3 DEVELOPMENT OF A NITROGEN-SPECIFIC GC DETECTOR FOR MEASUREMENT OF ATMOSPHERIC ORGANIC NITRATES.

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There is considerable concern regarding the steady increase of global oxidant concentrations, and in episodic oxidant concentrations that may endanger human health or cause vegetation damage. A complete understanding of the processes that control tropospheric ozone requires an understanding of odd nitrogen and how it is partitioned among the components (i.e. NO, NO_2, PAN, HNO_3, and organic nitrates). Recent atmospheric measurements indicate that not all of the measured total nitrogen can be accounted for by the measured individual components, and there has been much speculation that the "missing" nitrogen containing species are organic nitrates of the general formula $RONO_2$. Efforts to measure these compounds have been inconclusive, partly because of the large number of individual species that are possible, and because of the complexity of the GC/ECD chromatograms that are obtained with ambient air samples. To enable high sensitivity, high selectivity measurements of these species in ambient air, we have developed a novel GC detector for trace level measurements of organic nitrates. The detector is based on post-column thermal decomposition of the organic nitrates to produce NO_2. The NO_2 peak produced is then detected using a modified luminol- based chemiluminescence NO_2 detector. Because the detector responds only to NO_2, ambient air chromatograms, normally plagued with numerous peaks from organohalogen compounds, are greatly simplified. The detector makes it possible to measure the total concentration of organic nitrates. We have synthesized a number of alkyl nitrates (produced from OH reaction with alkanes), α,β-hydroxynitrates (from OH reaction with alkenes) and dinitrates (from NO_3 reaction with alkenes) that have been used for a detailed evaluation of the detector response, linearity and stability. The detection limit for these compounds is in the low picogram range. Ambient air samples were obtained during a study of oxidant formation at Hastings, Ontario, in August 1992, and analyzed using this detector. In this paper we will report results of our laboratory evaluation of the detector and present results of the Hastings study. We will also present details of our progress in development of a commercially available version of this detector.

BP3 STEAM-EXPLOSION DEINKING OF XEROGRAPHIC WASTEPAPER.

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Wastepaper is currently a serious concern in North America due to the shortage of landfill sites for its disposal. Office wastepaper, and xerographic (photocopier) paper in particular, poses a problem in that current technology is not satisfactory for its economic recycling. The feasibility of using a novel steam-explosion deinking technology for office waste recycling is therefore studied. The process involves treating xerographic paper at high consistency (50%) using high temperature (190-220°C) saturated steam for short duration (minutes). Steam-explosion was demonstrated to significantly enhance the cleanliness of the treated paper (measured objectively by computer-assisted image analysis) when compared to conventional laboratory pulping. Ink particle size and number were shown to be a function of process severity. There did not appear to be any significant difference in the response of different photocopier toners to the steam-explosion treatment. Up to 90% reduction in ink particle area and number could be achieved in the absence of washing, and without the use of any chemical during deinking. Pulp quality was further improved by using various selected surfactant during steam-explosion or in post-explosion cleaning treatment. Pulps of high brightness and low dirt count could be readily achieved. The potential of using steam-exploded xerographic paper in tissue (and possibly printing and writing grade) applications appears promising.

AP4 EXPERT SYSTEM SOFTWARE DEVELOPMENT FOR ASSESSMENT OF SOLID WASTES LEACHING AND DISPOSAL - LANDIS EXPERT SYSTEM.

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The LANDIS (LANd DISposal) Expert System program was developed as a decision tool to assist in evaluating the suitability of solid wastes for landfill disposal. LANDIS provides capabilities for solid waste assessment that were not previously available to regulatory agencies, planners, engineers, and researchers. It manages and interprets an extremely large and complex data set as well as render conclusions regarding testing requirements for solid wastes, the suitability of the wastes for landfill disposal, and waste processing options for wastes failing the disposal criteria.

A beta test version was released in June 1991 with accompanying documentation. Since that time, Canadian climate data and climatic factors have been added to the program to better simulate Canadian locations.

The landfill water balance model has been updated to allow for weather generation, and more complex landfill descriptions. A new water balance model interface has been developed utilizing state-of-the-art technology.

In the final phase of the project, the program will be expanded to include a wider variety of wastes. Regulatory agencies will be consulted in order to meet the current regulatory disposal practices in the different regions of Canada. This phase of the project will also contain complete validation of the knowledge base via a review of the rules by experts and several landfill disposal scenario assessments conducted by both experts and non-experts.

In order to address the problem of solid waste disposal, bench-scale batch leaching test protocols have been developed as a method of assessing contaminant release from a waste under a variety of conditions. These protocols do not consider any specific landfill site information. Thus, a logical extension to the current assessment protocols is to incorporate the characteristics of the target landfill site while utilizing the standard procedures and protocols to define waste characteristics.

The LANDIS Expert System guides the user thorough a solid waste assessment. The program utilizes a battery of leaching protocol types in conjunction with waste properties and target landfill hydrology to predict the controlling leaching mechanism and apply the leaching protocol test procedures most suited to this leaching mechanism. With this information, the concentration and mass loading of the contaminants of interest leaving the landfill over time can be calculated and projected in the future. The suitability of disposal of a specific waste in a specific landfill is determined, therefore, by the concentration or mass loading of specific contaminant species projected over time.

This project is jointly funded by the Environmental Technologies Program of Environment Ontario, the Canadian Electrical Association, and Dearborn Chemical Co. Ltd.

BP4 A DIFFERENTIAL OPTICAL ABSORPTION SPECTROMETER (DOAS) FOR ENVIRONMENTAL MONITORING

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Unisearch Associates Inc. is presently developing a remote sensing instrument capable of measuring automatically, simultaneously and continuously, air pollutants with high sensitivity and good selectivity. The principle of operation and analysis is based on the Differential Optical Absorption Spectroscopy (DOAS) technique. A beam of light is projected from a light source to a receiver over a pre-determined path. The light then enters a grating spectrometer. The selected spectral range is then either focused through a rapid scanning device (usually a slotted disk) onto a detector or, focused directly onto a photodiode array. The output signal, altered by light absorbing species, is then digitized and read by a computer where individual records may be averaged, analyzed, and stored.

The system will be used either in a remote sensing mode suitable for plume or air quality measurements, or, *in situ* measurements such as stack monitoring. It can also be used in field studies (such as EMEFS or Oxidant studies) to measure key atmospheric species, including a number, such as NO_3 and HO which cannot be measured by any other method.

Details will be provided of a prototype remote sensing DOAS system scheduled to be used to monitor NO_2, O_3, and NO_3 in a field study centered at Hastings Ontario during the summer of 92.

BP5 DEVELOPMENT OF A RANGE OF WATERLOO SCRUBBER PRODUCTS FOR FLUE GAS DESULPHURISATION

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Sulphur dioxide, the gas causing acid rain, is produced in utility power plants using sulphur containing coal or oil. More stringent SO_2 removal regulations have triggered a huge demand in North America for new technology and capital investment that will continue into the next decade.

The conventional commercial process for large scale SO_2 removal is scrubbing and reacting with finely divided limestone in slurry form, and is extremely capital intensive and generates gypsum (calcium sulphate) as byproduct which is then usually deposited as waste in landfill.

Recently, some of the large chemical companies have developed a range of proprietary amines which are very selective in their ability to remove sulphur dioxide. The flue gas stream is contacted with an aqueous solution of amine effectively absorbing >98% the sulphur dioxide and is then transferred to a conventional steam stripping stage where the reaction is reversed, and pure sulphur dioxide is recovered and the regenerated amine can be cycled. The sulphur dioxide can be sold as such or converted to sulphuric acid and then marketed.

Turbotak's research and development effort is focused on designing proprietary equipment that is suitable for such a process in both the absorption and desorption stages. Conventionally packed beds or tray columns represent the normal equipment for gas/liquid contacting but these are typically limited to a gas flow of ~10 fps and would result in units similar in size to the large limestone spray units. Additionally, such equipment can be prone to plugging unless clean liquids and gases are ensured which may not always be the case. Turbotak supplied a Waterloo scrubber absorber for a Union Carbide pilot plant of 1 MW size at Suncor's tar sands operations in Alberta. This pilot proved out the process concept successfully but identified the need for further development to establish all the design concepts for scaling the technology for units up to ~500 MW sizes.

These developments will examine: (a) Various absorber designs to optimize SO_2 removal efficiency at high gas flow velocities (~30 ft/sec or greater) (b)

Nozzle studies to evaluate co-current versus counter-current spray alternatives and nozzle systems for ducts >20' (c) Horizontal and vertical absorber designs (d) Minimization of energy consumption to ensure competitiveness with alternative absorber technology

Impacting the above studies are the effects of process variables such as temperature, SO_2 concentration in the stripped amine as well as in the loaded amine.

As part of this project, Turbotak Technologies Inc. will be developing a new concept for the steam stripping stage of the process. The sulphur dioxide loaded amine solution is preheated and then sprayed through a Turbotak two phase atomizing nozzle using steam as the atomizing gas phase. Preliminary experimental data has demonstrated the potential for equipment designs that will require lower capital expenditures and low levels of steam to achieve efficient sulphur dioxide removal. Success with this development could lead to a new range of products that would have broad application to all steam stripping processes.

AP6 PREPARING THERMOPLASTIC RUBBER COMPOUNDS CONTAINING GROUND RUBBER TIRES.

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The effective recycling of worn rubber tires presents a difficult but socially attractive option for the elimination of this discarded product. In the Polymer Materials Engineering laboratory at Queen's University research has been in progress to prepare high performance polymer alloys using in-situ reactive compatibilization. Attempts have been made to apply this approach to preparing plastic compounds which: - contain a maximum amount of ground rubber tire particles, - retain in the compounds the mechanical properties of the matrix plastic which is combined with the rubber, - retain processability of the compound so that it can be injection moulded into a wide range of products, - effect the above in an economical process. Early results had shown that readily available ground tire rubber (ambiently ground, 30 mesh) can be incorporated into linear low density polyethylene (LLDPE) at up to 50% with 50 - 70% loss in impact resistance. With the addition of a special reactive polymer (at 4%) the impact energy recovers to about 85% of the LLDPE but with incremental processing and material cost. More recent work has focused on the nature of the preparation of the ground rubber, some methods of modification of the ground rubber and the types of thermoplastics which can best be combined with the rubber. In all cases the compounds were prepared in a batch melt mixer and the material was moulded and evaluated on an instrumented impact tester. Ground rubber was sourced from many companies who use various grinding techniques. For the same particle size the wet ground material was a little better than the cryo ground which was a little better than the ambient ground materials. The smaller the particle sizes (in the range 600 down to 75 microns) the greater the impact strength but the differences were again not major. Plasma, coronna and electron beam radiation treatments have been applied to the ground rubber surface prior to compounding with the LLDPE and the electron beam treatment has resulted in about 25% improvement over the same good formulation without this treatment. Preliminary results to chemically modify the rubber to improve compound properties have only begun and no positive effects have yet been seen. Different polymer matrices have been evaluated including PVC, ABS, HIPS, PP, PPcopolymer, as well as various polyethylenes and, in general, the properties are very poor with the more brittle polymers but much better with more ductile polymers. It is felt that with further work there are reasonable chances of preparing plastic compounds with useful properties in an economically viable manner.

BP6 REMOTE VEHICLE EMISSION SENSING SYSTEM: FEASIBILITY STUDY

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Sciencetech Inc. has carried out a detailed feasibility study into the possibility of building an instrument which will remotely monitor exhaust emissions from moving vehicles. The study received joint financial support from the Ontario Ministries of Environment and Transportation, and was conducted over a four month period in the summer of 1992.

Vehicles which burn fossil fuels emit carbon dioxide and water as normal combustion products. Although the first of these is a greenhouse gas, it has no other immediate environmental impact. If an engine is not operating ideally, however, as is the case for most vehicle engines in actual use, several other exhaust products of more immediate environmental concern are generated. These include carbon monoxide (CO), hydrocarbons (EC, mostly derived from unburned fuel), and nitric oxide (NO). For diesel engines, particularly trucks and buses, smoke containing microscopic carcinogenic carbon particles is also emitted. All of these exhaust components contribute significantly to environmental pollution, smog, and general health risk.

The study reported on in this paper involved assessment of available technologies for remote measurement of trace gases, and of smoke opacity. This research has led to the development of a conceptual design for an instrument which can observe the exhaust plumes of passing vehicles from the roadside, and assess the emission levels of critical pollutants. Threshold levels for specific pollutants would allow excessive emitters to be identified, and potentially charged.

The instrument may take different forms, and may be used in different ways depending on the target vehicle type. The deign concept includes flexible implementation and complexity, to accommodate a variety of specific applications. A preliminary market analysis reveals promising potential marketability of such a

remote exhaust monitor, particularly for heavy duty diesel trucks, in the United States and other major industrial countries.

Ontario currently has no detailed emission regulations for in-use vehicles, although guideline emission standards based on the U.S. regulations do exist for automobiles. The development of an instrument such as that recommended in this study would facilitate the establishment and enforcement of emission standards, leading to improved protection of both health and environment in Ontario.

AP7 ELECTRIC VEHICLES AND THE ENVIRONMENT

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Motor vehicles are one of the major contributors to atmospheric pollution, emitting significant quantities of carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons (HC) and oxides of nitrogen (NO_x). Automotive emissions degrade air quality (especially in an urban environment); they contribute to the greenhouse effect, acid rain, and ground level ozone; and they add toxic materials such as benzene, aldehydes, butadiene, and diesel particulate to the air. This situation has spurred interest in electric vehicles (EVs) as an alternative to internal combustion engine vehicles (ICEVs). Recently passed California legislation requiring 2% of all new vehicles sold in that State to be zero emission vehicles starting in 1998, has stimulated activities by the automotive and battery industry.

The environmental impact of EVs depends largely on the mode of electricity generation. In Canada, this is very significant variable due to the wide variation in power generation mix from region to region. British Columbia and Québec generate more than 90% of their electricity from hydro, whereas over 90% of Alberta's power comes from burning fossil fuels such as natural gas, oil and coal. Ontario, on the other hand, relies on nuclear power for about 50% of the Province's electrical demand. Other important factors in determining the environmental impact of EVs include the overall efficiency (km/kWh) of EVs and the emissions from existing ICEVs that are to be replaced by EVs.

The determination of the net emissions displacement taking into account the above factors is facilitated by a computer program developed at ESTCO with a grant from the Ontario Ministry of the Environment. The structure of the program and results are described in the paper.

BP7 DEMONSTRATION OF THE ECO LOGIC PROCESS OF HIGHLY CONTAMINATED PCB WASTES.

K. Campbell, ELI-Eco Logic International Inc., Rockwood, Ontario.

Environmental need for a cost-effective, safe, permittable alternative to incineration for the destruction of highly hazardous wastes such as PCBs and the remediation of hazardous waste landfills, leachates, lagoons, soils and contaminated soils and harbour sediments.

During the Demonstration test of the pilot-scale field demonstration unit on Hamilton Harbour PAH (coal tar) contaminated sediments, performance run 3 included PCB spiked sediment (500 ppm) which resulted in destruction removal efficiencies (DRE's) of 99.9999%.

Due to successful results at Hamilton Harbour, the United States Environmental Protection Agency has requested Eco Logic to further demonstrate the mobile field demonstration unit of the Eco Logic Process under the auspices of the Superfund Innovative Technology Evaluation (S.I.T.E.) Program on PCB, and the TCE contaminated leachate extracted from the Middleground Landfill in Bay City, Michigan. The demonstration will include an additional front-end thermal desorption unit which will increase the throughput of the process for soils to 25 T/day. The demonstration schedule also includes processing of 40% PCB oil in trichloroethylene contaminated groundwater and performance runs of 72 hour durations.

A 100 ton commercial scale mobile field unit is planned following the Michigan project.

Following the EPA project, the Eco Logic organic hazardous waste destruction technology will be recommended for use at Superfund sites in the U.S. In addition, the S.I.T.E. program should lead to the regulatory approval of the process for remediation of sites and destruction of PCBs throughout Canada and the U.S.

AP8 ON LINE MICROWAVE DIGESTION FOR ENVIRONMENTAL SAMPLES

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Elemental analysis of environmental samples can now be accomplish in seconds by means of AA ICP and/or ICPMS. However, preparation of samples prior to analysis is still time consuming and labour intensive. Questron already manufactures batch systems for sample preparation by Microwave digestion. Although these systems have demonstrated that the actual digestion times can be sufficiently reduced, they are still labour intensive, because they require an operator to load, unload, and clean vessels. It is the goal of this project to develop a commercial system, to be manufac-

tured by Questron Canada Inc., which will prepare samples at a production rate, and level of automation equal to, or better than, the finest AA, ICP and ICPMS systems. Our overall objective is the development of a system for preparation of both liquid and solid environmental samples. However, the first phase in the progress of an On Line Microwave Digestion System is for preparation of water, wastewater and other environmental liquid samples. This paper deals primarily with the progress of the prototype liquid system. We will describe the system, and results obtained for preparation of liquid samples, which have been provided by a commercial environmental testing lab. Finally, we will review the quality and commercial impact of this system on work being done at the Ministry of the Environment, and commercial testing labs in Canada, and abroad.

BP8 THE ECODYNE SYSTEM: AN ENVIRONMENTAL TOOL FOR AQUATIC STUDIES

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Environmental studies conducted *in situ* in the water environment often require containment of one or more investigated species in order to understand their behaviour or survival under natural conditions or various levels and types of stress. For larger species this may only present a logistical and physical challenge because containers with a restrictive mesh will still permit free circulation of natural waters without impairing gas exchange or changing water quality parameters. Smaller species, and microorganisms in particular, present a much greater challenge in this regard. As a result, many such investigations are conducted in the laboratory or in closed containers in which exhaustion of metabolizable substrates and accumulation of toxic wastes rapidly occur. This can make conditions unfavourable for some species and favour others, depending on the species composition. Data obtained in such "batch" systems must be scrutinized very carefully because chemical composition and other parameters of water quality will be different in closed containers from those in natural waters. We have developed a device (the ECODYNE system; patent pending) which will allow us to study even the smallest microorganisms *in situ* while retaining natural water quality and chemical composition. Moreover, virtually instantaneous diffusion of dissolved substances between a compartment containing the species of interest and the exterior environmental compartment, which can be a lake, river or other body of water, permits the ECODYNE system to respond instantaneously to most changes in water quality parameters. This gives it a unique capability to be used for real time toxicity studies in the field.

The basic ECODYNE system is versatile in design and application, and its use for microbial species or other sensitive organisms will make it a useful tool in a variety of water quality research issues. In essence, its utility is as a tool to deliver toxics, nutrients etc. to the contained species and it should be particularly useful for studies where chronic exposure to low levels of toxins is a factor. In addition it can be used to provide greater realism to aquatic microcosm studies. Because of its properties, we consider it relevant to the Ontario Ministry of the Environment in its responsibility for water quality in Ontario, with potential in many specific areas, including, in no particular order:

1) disinfection of pathogens and nuisance organisms in drinking water
2) modelling microbial fate and transport (including indicators of water quality and genetically modified microorganisms)
3) on site evaluation of toxicity to aquatic organisms of various waters, such as municipal sewage, pulp mill or other industrial effluents.
4) evaluation of effects of wastes on aquatic ecosystems. Some process wastes may be nutritive for some species but toxic to others with a resultant disruption of natural ecological processes.
5) evaluation of interspecies interactions and how they can be altered by pollutants.
6) assessment of reductions of increases in toxicity as a result of process changes in industry.
7) evaluation of biodegradability of organic contaminants in natural waters or sewage treatment systems.
8) test system to examine efficient removal of toxic substances by biological agents.
9) to study the effects of acidification on ecological processes and toxin (e.g. heavy metal) mobilization.
10) to study translocation and interconversions of instream pollutants.
11) to conduct chronic toxicity studies using naturally occurring levels of toxins.
12) to assess the effects of non-point source pollutants on ecological processes
13) to examine impacts of pesticides (insecticides and herbicides) on components of aquatic ecosystems and look at distribution between components.

In addition to laboratory characterization, we have conducted field trials of this system in local rivers and stormwater retention ponds where the focus was the survival of microbial indicators of water pollution (bacteria, human viruses and bacteriophage), as well as pathogens. In all these studies, we have compared survival in the ECODYNE system with that in a closed system. The results have shown considerable variation in indicator survival between various bodies of water, and, in the case of nutrient rich waters with rich algal growth, even at the same site in the same water course over time. The rapid decline in indicators at certain times was suggestive of species antagonism whereas regrowth supported on other occasions indicated that fresh nutrients were available to the bacterial species. Further field trials are planned to show whether and how algal blooms may affect the survival/die-off of these indicators and representative bacterial and viral pathogens throughout the summer. This research has implications for the routine water quality monitoring, and rapid reductions or regrowth of indicator species may raise questions about their usefulness as indicators in nutrient rich/eutrophic waters.

AP9 ADDING VALUE TO ROADS WITH WASTE PLASTICS

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Polyphalt Inc. is developing and commercializing a new generation of asphalt materials based on technology developed at the University of Toronto which combines recycled plastics and other polymers to form cost effective pavements which last longer, require less maintenance, and provide a smoother and safer ride for motorists. The high added-value component of the roads and highways produced by the process should ensure the creation of a significant and sustainable downstream market for waste plastics. Asphalt modified by the Polyphalt process can be engineered to meet specific criteria for any given pavement application and will also bring benefits to the roofing, coatings, and sealants industries. Polyphalt is a private Ontario company which holds worldwide rights to the technology.

BP9 BIOFILTRATION OF TOXIC METALS FROM ACID MINE DRAINAGE THROUGH ACTINORHIZAL SYSTEMS

L. Chatarpaul and M. Kean, M. Kean Resources, Timmins, Ontario.

Despite concerted efforts by government and the mining industry to stabilize mine tailings, acidic water often loaded with heavy metals continue to flow and contaminate surrounding environments through seepage and run-off. This project was launched with the aim of developing an alternative biologically based system to be tested for the removal of toxic metals from acid mine drainage. A key ingredient in this approach is the role certain plant/microbial symbioses referred to as actinorhizal and to which the target genus, *Alnus*, (alder) belongs. Still in its first year, the project's activities include a literature survey, site evaluations, seed and microbial collections, a survey of an AMD area for alders and their metal levels, and a greenhouse study of uptake/tolerance of an actinorhizal system to several common metal contaminants. The results of these activities will be presented in the paper. Evidence of biomass accumulations, benefits of microbial interactions and high metal/low pH tolerance of this actinorhizal system point to a potential tool. The next phase of the project involves the installation of a test plot using these plants at an AMD site. Following further evaluations, this company hopes to produce a biofiltration system for wider applications.

AP10 REMOVAL OF SELECTED HYDROCARBONS FROM SOIL USING *Pseudomonas aeruginosa* UG2 BIOSURFACTANT.

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Biosurfactants are amphipathic compounds produced by microorganisms which bind to interfaces, causing a reduction in surface or interfacial tensions. Surfactants may also act as emulsifiers, increasing the solubility of hydrophobic compounds. *Pseudomonas aeruginosa* UG2 was isolated from an oil contaminated soil. This microorganism produces 2 different rhamnolipid biosurfactants, which have been tentatively characterized by NMR and GC-MS analysis as α-L-rhamnopyranosyl-β-hydroxydecanoate and 2-O-α-L-rhamnopyranosyl-α-L-rhamnopyranosyl-β-hydroxydecanoyl-β-hydroxydecanoate. UG2 rhamnolipid surfactants have potential in the remediation of hydrophobic compo unds from a soil environment.

Hydrophobic compounds such as hydrocarbons are important environmental pollutants, which bind to soil particles and are difficult to remove or degrade. Efficient degradation requires that hydrocarbons be solubilized prior to utilization by microorganisms. Surfactants can emulsify hydrocarbons, thus enhancing their water solubility. Also, surfactants can decrease surface tensions and increase displacement of oily substances from soil particles.

P. aeruginosa UG2 biosurfactant was able to enhance the aqueous removal of a mixture of 8 hydrocarbons from soil. In batch soil washing and soil column experiments, UG2 biosurfactant enhanced the removal of hydrocarbons from soil to the aqueous phase. Experiments are also being performed to study the effects of UG2 biosurfactant on microbial degradation of hydrophobic pollutants in soil. These results show that UG2 rhamnolipid surfactant may be used to enhance the recovery of pollutants from contaminated soil.

BP10 GENETIC ENGINEERING OF COMMERCIAL POTATO CULTIVARS FOR VIRUS RESISTANCE.

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The coat protein gene of potato virus X (PVX) introduced as a chimeric gene under the control of the cauliflower mosaic virus 35S promoter into potato using a disarmed binary vector and *Agrobacterium tumefaciens* transformation system. We efficiently transformed four commercial cultivars of potato (*Solanum tuberosum*), Russett Burbank, Shepody, Desiree and Bintje from potato tuber discs and stem explants. These plants express the gene for the coat

protein (CP) of PVX. Eleven transgenic clones with expression levels of CP higher than 0.5% of soluble leaf protein were analyzed for resistance to a challenging inoculation with PVX (5 ug/ml). We observed a reduction in the accumulation of virus in transgenic plants. Phenotypically all these plants appeared normal. Furthermore, we found that CP gene is very stable and in the case of a high expressor such as clone 304, CP gene is transferred to new plants originated from shoot cutting of the mother plant and in F1 and F2 progeny resulted from growing the tuber. Other approaches such as the use of ribozymes designed to splice specific important viral genes (e.g. viral RNA polymerase) and the expression of pokeweed antiviral protein (PAP) in transgenic plants will also be discussed. These results confirm that the development of virus resistant varieties would be one of the most effective means of controlling viral diseases in potato. Consequently, the use of chemical pesticides for the control of insects which transmit viruses may be drastically reduced.

AP11 EXPERIMENTAL AND THEORETICAL STUDY OF GUELPH'S PILOT SCALE SOLID WASTE COMPOSTER, A TEMPERATURE FEEDBACK CONTROL STRATEGY

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Detailed operating data and experience obtained during the first year of operation has lead to the development of a temperature feedback control system. The temperature profile taken in the first year showed that temperatures could reach above 70°C in the centre of the biomass. Supporting research has proven that metabolic activity is significantly slower at this temperature.

A control system was developed using continuous by recording temperature sensors to automatically control the quantity and frequency of airflow to the primary compost reactors. For this purpose each primary was retrofitted with a separate blower and piping system and a differential pressure transducer was used to read the incoming airflow. The system ensured that the set point temperature of 60°C was not exceeded, while supplying the required oxygen to the aerobic microorganisms. This created a thermophilic phase which is ideal for rapid degradation of most organic matter with the exception of the more calcitrant cellulose and lignin macromolecules.

This paper describes a simultaneous control and data acquisition system for a pilot-scale MSW composter. Simplified algorithms are provided to show the software developed to provide the system with this multi-role capability. As an illustration of operation, the primary stage of composting is shown for two different MSW batches run in the spring of 1992. The success of the control system to maintain a 60°C set-point in the hottest location of the biomass is determined using temperature versus time plots and by the recorded demand of blower operation. The daily volume of air required by the compost piles are also provided for both batches. The data obtained from this system enable designers of central composting facilities to correctly size the aeration system.

BP11 BIOCONVERSION OF MSW PAPER TO FUEL ETHANOL: A WASTE REDUCTION PROJECT:

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Results, summarized in the FINAL REPORT of JULY 1, 1992, include: definition of a process for bioconversion of waste paper to fuel ethanol ready for commercialization; an outline of improvements to be made during commercialization; bioconversion to ethanol of the paper enriched fraction from Materials Recovery Facilities (RDF); the value of steam pretreatment for ethanol yields; new processes for cellulose enzyme production. The FINAL REPORT includes an economic analysis, and how to achieve acceptable profitability; and flow charts and mass balances for two conversion plants, one accepting 4 tons of waste paper per day, and the other accepting 400 tons of waste paper per day. Both are part of waste paper conversion plant projects in Europe (Switzerland, Germany). The main thrust of further technology development will be to bring the enzyme production process up to the best industrial standards. BV employing a relatively simple process consisting of enzymatic liquefaction followed by combined saccharification and yeast fermentation, yields of 400 liters of ethanol per ton of waste paper are obtained. When acid-catalysed steam pretreatment was employed, yields were 460 liters per ton, about 85% of theory. Paper-enriched fractions obtained from Materials Recovery Facilities also gave very high yields based on their cellulose content. The enzymes employed were made here as part of the process. It is estimated that fully in place the volume of MSW going to landfill would be reduced by about 40%. There is enough waste paper in MSW to displace about 10% of the fuel now used by Ontario's motorists with the environmentally friendly, high octane, non-petroleum ethanol motor fuel.

AP12 SOLID WASTE STABILIZATION IN A LANDFILL ENVIRONMENT.

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The major long-term concern with disposal of solid waste in sanitary landfills is the ultimate fate of the components. In particular, material is leached out of the waste by infiltrating precipitation and this can lead to contamination of adjacent groundwater. Therefore, the processes by which landfilled waste becomes stabilized into a final, inert mass are important in determining the

potential environmental impact of these sites. In this project, the important stabilization mechanisms for inorganic species in a landfill were deduced by obtaining a direct, detailed view of the distribution of various elements within columns containing codisposed municipal solid waste and an alkaline industrial waste (steel flue dust). Thus, after five years of leaching, several columns were frozen, portions of the undisturbed contents were removed, and cross-sections prepared for microscopic examination and *in situ*, quantitative analysis. This technique provides a unique view of the actual speciation and pattern of heavy metal immobilization that can occur in landfills which in turn reflects the processes that were involved. The distribution of the elements indicates the crucial role played by hydroxide and, more importantly, by carbonate in the precipitation and hence immobilization of many metals in these columns. In contrast, there is no evidence of any appreciable immobilization by sulphide precipitation nor by adsorption, despite the important roles often attributed to these mechanisms. This precipitation of heavy metals by carbonate in the codisposal columns is so efficient that, despite containing much higher levels of many metals than control columns composed of municipal solid waste only, the codisposal columns produced a leachate that contained the same or lower levels of these metals. This study demonstrates the efficacy of the codisposal of selected industrial wastes and also of alkaline additives with municipal solid waste in stabilizing landfills and decreasing the release of heavy metals in the leachate.

BP12 EVALUATION OF THE CAPACITY OF PEAT TO ATTENUATE LANDFILL LEACHATE.

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The main objective of this study is to determine the suitability of using peat soil as a filtering medium, capable of long-term attenuation of the compounds usually present in a landfill leachate solution. This study is also focused on establishing the necessary parameters required for the design of a natural attenuation system such as peat trench and/or a peat bed which will offer a pretreatment to the migrating leachate solution before its release to the subsurface environment.

The parameters include the retardation factors of various contaminants which will come into contact with the filtering media, the required hydraulic loading, the optimum density and compaction of the peat filtering media and the prediction of the long-term performance of the system.

The initial phase of this research project was focused on the selection of an appropriate peat source in close proximity to the site. A number of potential peat sources were identified and representative peat samples were submitted to identify its physical and chemical characteristics. At the conclusion of this phase, the preferred site was identified and samples of the peat were collected for further analytical investigation to determine the adsorption isotherms, the migration profiles and the breakthrough characteristics of various contaminant species. The adsorption isotherms were established using a batch study, while the migration profiles and the breakthrough characteristics were determined using continuous flow permeating through leaching columns. The leaching column study was carried out to simulate the continuous anaerobic flow of leachate that would occur in the constructed peat trench. Lead, zinc, calcium, sodium and organic matter were examined during the course of this investigation.

This paper presents the results of the batch and continuous flow testing, as well as discusses the various mechanisms responsible for the adsorption or desorption of various contaminants.

AP13 MODELLING LINER-LEACHATE COMPATIBILITY

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Compacted clay liners are used to contain landfills and prevent municipal solid waste (MSW) leachates from entering the ground water. These liners are engineered to have hydraulic conductivities less than 10-9 m/s so that advective transport is extremely slow. Solutes move into, and through, the liner, however, due to molecular diffusion.

If the liner contains clay particles having relatively high sorption properties, the effects of solute diffusion will be mitigated by partitioning and cation exchange. It has long been speculated that sorption phenomenon may cause shrinkage, and possibly collapse, of clay lattice structures, particularly those of the smectite family (montmorillonites, chlorites, vermiculites) producing significant increases in advective transport. Several researchers have permeated compacted natural clay materials with various organic liquids and found increases in hydraulic conductivity of the clay. This effect is known to be mitigated to some extent when the clay is permeated under an effective vertical stress. Apparently the effective stress closes cracks and voids caused by geochemical phenomenon. Understanding these phenomena is complicated by boundary effects introduced using flexible or rigid walled permeameters.

Because a geotechnical centrifuge is capable of accelerated modelling of contaminant transport through clay liner models under the field (prototype) effective stress conditions, it is an ideal method of examining clay liner compatibility with any potential leachate. A flexible, no lateral strain boundary condition was developed for centrifuge modelling and this paper reports results of liner-leachate compatibility modelling in a 1m diameter centrifuge designed and built for the purpose of evaluating clay liner performance characteristics.

BP13 AN ENGINEERED LANDFILL LINER UTILIZING COAL FLY ASH

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The research performed in this project investigates the performance and behaviour of a novel landfill liner. The potential use of coal fly ash as an economic alternative construction material for a landfill liner has been recognized. The feasibility of the large volume utilization of this bi-product, which is freely available, from coal burning power stations will help to reduce the construction cost of landfills. The suitability of using coal fly ash as a landfill liner construction material is determined by the effects of leachate that is produced by municipal solid waste (MSW) on the hydraulic properties of the liner and by the amount of chemical contaminants retained by the liner during its life time. In this work, hydraulic and chemical barrier properties of the liner material made from an Ontario coal fly ash are investigated, at a laboratory scale. The investigation focuses on the liner's capacity to retard the movement of metals from a simulated MSW leachate. The test specimens are compacted blends of class F fly ash, low in calcium content, lime kiln dust, calcium-bentonite and water. The simulated leachate is passed through the specimens under a gravitational head, and the hydraulic conductivity and the diffusion of elements in the leachate through this material are monitored. The capacity of the fly ash blend to immobilize metal ions was found to be directly related to its pH, the metal solubilities, the amount of free lime and the amount of carbonates. Thus, the breakthrough point of the metal ions and the change of hydraulic conductivity provide prediction of the anticipated life and performance of the liner.

AP14 REDUCTION OF NITROGEN LOSSES FROM ANIMAL MANURES BY STABILIZATION WITH AMMONIUM ADSORBING MINERALS.

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Ammonia loss from animal manures has an adverse effect on the air quality of livestock enclosures and reduces the nutrient value of the manure. The application of animal manure containing large quantities of ammonium increases the potential for rapid nitrate production and the contamination of surface- and ground-waters. The rate of ammonium release from these materials, when added to the soil, is an important consideration in assessing the efficiency of nitrogen use by the crop and the potential for NO_3 contamination of groundwater. This project examines the potential for using ammonium adsorbing materials to reduce ammonia loss from animal manure in livestock enclosures and storages and the subsequent release of ammonium when applied to soil.

The first phase of the project involved the selection of appropriate adsorbing materials. Only materials considered to be suitable for land application were tested. Naturally occurring geological materials (bentonite, zeolite and vermiculite) as well as two peats were examined based on their high adsorption and cation exchange capacities and their practicality (cost/supply). The chemistry, mineralogy and ammonium exchange characteristics of each of these materials was determined to assess their suitability.

The rate of ammonium release from each material once added to soil was determined in the second phase of the project. The release of $^{15}NH_4^+$ from saturated adsorbents applied to medium- and coarse-textured soils was examined in a laboratory study. The rate of NH_4^+ determines the suitability of each material as an N source in cropping systems.

The final choice of the materials to be used will be based on the exchange characteristics, ammonium release characteristics, availability, cost and handling characteristics. The use of ammonium adsorbing materials in livestock enclosures would have beneficial impacts on the air quality of these enclosures and water quality on sites where the manure is being applied.

BP14 RECOVERY OF HEXAVALENT CHROMIUM FROM ELECTROPLATING WASTE USING LIQUID MEMBRANE PERTRACTION

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Hexavalent chromium has long been recognized as a toxic substance due to its strong oxidizing potential and ease with which it can cross biological membranes. Current disposal techniques involve precipitation of the chromium as a +3 oxide followed by disposal in a landfill site. This approach does not allow for metal recovery and transfers the problem from the contamination of a wastewater effluent to one of solid waste disposal. The objective of this research is the development of liquid membrane pertraction for the selective removal and concentration of chromium (VI) from electroplating wastes so that the chromium can be recycled directly back to the electroplating operation. In this way, hazardous waste disposal and electroplating costs are reduced.

This study is concerned with the engineering aspects of the design and optimization of a membrane pertraction separator and the chemistry of the solvent extraction process. Liquid membrane pertraction combines the loading and stripping steps of solvent extraction in one unit which can be run continuously. The advantage of this process over most liquid membrane-based techniques is that all three liquid phases are continually flowing, resulting in enhanced mass transfer, increased membrane stability and greater flexibility with regard to control and optimization. In addition, any or all three phases can have a recycle stream.

One of the difficulties in liquid membrane technology is in keeping the organic and two aqueous phases in an easily separable form, while maximizing the interfacial area between them. This has been achieved in this study by exploiting two important properties of the system: (i) the immiscibility of the aqueous and organic phases, and (ii) the difference in specific gravity. The three-phase flow in the separator involves the downward flow of the aqueous feed and strip solutions through an alternating sequence of vertical hydrophilic supports. The organic phase is unsupported and flows freely in the spaces between the supports. Viscose has been chosen as the support material because of its low cost, high stability and high permeability. The primary variables of interest in this study have been the relative flow rates of the three phases and the spacing between the supports.

Laboratory solvent extraction studies were conducted to study the effects of pH and chromate/sulphate concentration ratios in the feed and strip solutions. The liquid membrane consisted of a tertiary amine (tri-n-octyl amine) carrier in a kerosene solvent. A modifier (2-ethyl hexyl alcohol) was added to inhibit the formation of a stable emulsion phase. The most significant variable appears to be pH. For the liquid membrane system used in the experiments, optimal loading and stripping were found to occur under acidic and basic conditions, respectively.

A more detailed description of the design, as well as key findings from the solvent extraction studies, will be presented.

AP15 *IN SITU* BIOREMEDIATION OF DISSOLVED CHLORINATED SOLVENTS USING A NOVEL NUTRIENT INJECTION SCHEME

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The reductive dechlorination of compounds such trichloroethane (TCE) and carbon tetrachloride (CT) has been shown to occur in highly anaerobic environments such as those characterized by the presence of methanogenic bacteria. Recent research has demonstrated that this process can result in the complete removal of chlorine atoms from the repetitive organic molecules.

Aquifer material and groundwater were obtained from the CFB Borden test site and used in microcosm and column experiments to determine the feasibility of stimulating methanogenic bacteria from initially aerobic material. Anaerobic conditions suitable for reductive dechlorination of TCE and CT were obtained from both experimental setups. Methanogenic bacteria were active in both experiments, as indicated by the appearance of substantial quantities of methane.

A field experiment at the CFB Borden test site is underway conducted in which the nutrient solution used in the laboratory tests was injected into a shallow sand aquifer. A novel injection scheme was developed which overcomes the difficulties of mixing the nutrient solution with the groundwater in directions transverse to flow, and takes advantage of the actual tendency for mixing in the principal direction flow. The aquifer is being monitored for geochemical changes and the appearance of methane. Finally, a slug of TCE and CT contaminated water will be injected into the system and the two organic species and their transformation products will be monitored.

BP15 THE EFFECTIVENESS OF A STORMWATER MANAGEMENT POND IN THE REMOVAL OF URBAN CONTAMINANTS FROM STORMWATER.

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According to Environment Ontario, the most common structural BMP used in Ontario is the water quality pond. Most designs have concentrated on the basic sedimentation capabilities of the devices in attempting to address stormwater quality concerns. Ponds provide many other benefits and can be designed to provide environmental opportunities and enhanced water quality control. Ponds are likely to continue to be an important element in stormwater quality control. Their limitations need to be recognized however. In some cases the problems associated with ponds can be overcome by design. As the capability of an on line stormwater control pond to improve water quality while subject to natural flow variations is not well known, it is necessary to collect and analyze data from existing online detention ponds in an attempt to characterize the hydrologic/water quality processes. Only through this analysis can the value of detention ponds in the control of stormwater quality be determined.

The research involves the study and monitoring of an on-line stormwater management control pond in Kingston Township with the object of characterizing the ability of the pond to remove water borne contaminants from the stormwater. A field survey program was implemented to determine the characteristics of the creek and the drainage area which includes the Cataraqui Town Centre, pond bathymetry, and the location and degree of connectivity of paved areas. Weirs were designed and constructed by the Department of Civil Engineering for the storm water inlet, the creek inlet to the pond, and the outlet from the pond. Rating curves for the weirs were derived and verified by stream gauging. A data collection system was installed. It included a tipping bucket raingauge, floats and shaft encoders for water level monitoring, a data logger, and automated water quality samplers.

A chemical analysis program involved determination of natural background levels of chemical constituents in the runoff and in the pond sediments, chemical analyses of water inflow and outflow during selected storm events and during inter-storm periods. Field and laboratory studies were conducted to characterize the vegetation and biota in and around the stormwater pond. Bacterio-

logical analyses of inflow, outflow and pond water included tests for fecal coliforms, *E.coli* and fecal Streptococci.

In order for the informed development of provincial guidelines for stormwater quality control, there is a need to understand the major processes affecting the mass transfer of critical pollutants including both persistent toxics and nutrients within the urban ecosystem encompassing stormwater ponds, and to assess environmental impacts of stormwater ponds by ecotoxicological methods. The first step is to determine mass balances for water, sediment and key contaminants for wet ponds under Ontario conditions.

AP16 SOLID WASTE PRODUCTION IN LAND BASED CULTURES OF RAINBOW TROUT (*Oncorhynchus mykiss*)

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Solid waste is produced in a land based rainbow trout culture system in the form of uneaten and undigested food. The production of non-filterable solid wastes during normal operations in such a system was modelled and monitored on a monthly basis over the growth range 30 grams to 350 grams. Solids were collected from two experimental clarifiers which were located in series with separate experimental fish populations. The clarifiers were designed to operate at an overflow rate of 0.067 m^3/m^2 min. Results from the analysis of the solids collected from the two experimental fish populations were applied to determine design requirements for clarification of flocculant suspensions by settling, thickening of settled solids and control of total phosphorous in the effluent from fish holding systems. The feasibility of achieving current effluent quality standards of suspended solids and phosphorous was evaluated for normal and cleaning operations. Also the investigation provided guidelines for the design of solid waste management works, required at different stages of fish growth, in new fish culture systems and in retro-fit of existing systems.

BP16 TO DEVELOP A RELIABLE, ECONOMICAL AND ENVIRONMENTALLY SAFE METHOD OF MILKHOUSE EFFLUENT DISPOSAL

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Milkhouse effluent is a particularly awkward waste product for small dairy producers who handle their manure as a solid. These producers are not equipped to store and spread the large volumes of liquid produced from the cleaning of their milking systems. One alternative disposal system which seems to meet the needs of these producers is the septic system. Septic systems are relatively inexpensive, require little operator attention, and eliminate the need of spreading liquid waste. The problem with disposing of milkhouse effluent through septic systems is that the infiltration area or "weeping tile field" tends to clog with milk fats. A thick oily film seals the interface between the crushed stone and the side walls of the infiltration trench. If continually loaded, this film may become impermeable within the first year of operation. This causes water to back up through the system and onto the milkhouse floor. It may be possible to avoid the clogging problem by improving management practices and modifying the design to match site conditions. Improved management practices were evaluated by analyzing samples of effluent from two milk houses. The key to effective management is to reduce the amount of milk allowed into the infiltration system. This can be achieved by rinsing 5 to 10 l of water through the milking apparatus immediately following milking and feeding this milky water to the calves. Mass loading of total suspended solids and chemical oxygen demand (parameters which have been linked to clogging) were reduced by over 65% and 60% respectively by removing the first rinse water. Designs must account for difficulties such as high water tables, slowly permeable subsoils and high bedrock. A modified design is being tested on a clay subsoil using a full scale experimental prototype. The experimental system includes a two compartment baffled tank, a pump chamber and a raised filter bed. The tank was baffled to lessen flow short circuiting and promote solids removal. The filter bed is composed of a layer of peat soil overlying a layer of sand. Peat was chosen as a filter medium because: the irregular shape of its particles provides a large surface area for adsorption; its high porosity promotes aerobic conditions which lessen the chance of clogging; the organic content should provide a suitable medium for microorganisms. The system has been loaded with milkhouse effluent, excluding the first rinse water, for one year. A small scum layer has formed and some solids have settled to the bottom of the tank. No clogging has been detected in the mound, but some surface leaching has occurred. The surface leaching has been attributed to channels formed within the mound due to uneven compaction. Better construction methods have been developed so that compaction will be uniform. TKN, COD, TS, TSS, TP, O-PO_4 have been monitored throughout the system. Nitrogen concentrations have been low. Most of the solids are dissolved. COD and TSS are reduced to at least half influent concentrations within the bed. Phosphorous is not retained in the bed, but should not be mobile within the native clay.

AP17 REMOVAL OF SPECIFIC POLLUTANTS BY A QUASI BIOLOGICAL PROCEDURE.

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Organisms in nature are very accomplished at concentrating specific elements or compounds from a low natural concentration to a high intracellular concentra-

tion. A rationalization for the synthetic mimicry of this process will be presented. The technique will then be applied to the removal of H_2SeO_3 from the electrolysis liquor of electrolytic copper refining. Approximately 280,000 tons of copper per year are produced in Ontario. With an average value of 400 ppm selenium this represents 1000 tons of toxic selenium per year. A process to recover the selenium as a saleable product will be described.

BP17 DEVELOPMENT OF THE TRAP-TREAT-RELEASE TECHNIQUE FOR PESTICIDE MINIMIZED TERMITE COLONY CONTROL.

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The sheer quantity of persistent chemical termiticide that is used in the conventional chemical soil barrier method of subterranean termite control poses a major environmental concern. One hundred to one thousand times more toxicant is applied per square meter of soil than is generally used in other types of chemical pest control. Recent advances in development of the trap-treat-release technique of subterranean termite control indicate that it may soon be possible to control termites with about 1/5,000 as much chemical toxicant. The most critical problems involved in the development of the trap-treat-release technique were the development of a waterproof topical formulation that could be groomed by untreated termites from treated carriers, and secondly, the development of a rapid application method for treating large numbers of trapped termites with a uniformly heavy dose with minimal behavioural impairment and low casualty rates. Extensive experimentation has led to the solution of these problems. The specific nature of the formulation and application techniques involve proprietary information and can not be disclosed in detail. However the general feasibility of the trap-treat-release control strategy has been convincingly demonstrated in large scale laboratory tests with entire miniature termite colonies (50,000 termites) established in "house units" which simulate real conditions of the subterranean micro-environment and the basic elements of wood-frame construction. Four replicates each with a 50,000-termite-house-unit control were conducted with a 5% release of treated termites and achieved total control within one month. House-unit tests with 1% treated termites are now being initiated. Such phenomenally low effective treatment ratios were not unexpected since previous studies had achieved lethal transmission ratios in excess of 1:300. It is anticipated that total eradication of field colonies can be achieved with ratios of transmission of only 1:10 since we are able to trap around 10% of the colony population. The higher the effective transmission ratio the less effort one would have to invest in trapping. These experiments have demonstrated the highest ratio of social transmission of toxicants ever reported in subterranean termites and also report the largest contained populations ever to be eradicated. The next phase of research will involve field evaluation, formulation and application improvements, evaluation of additional actives, and integration of the trap-treat-release with non-chemical control practices. The trap-treat-release technique is the ultimate embodiment of the insect pest management dictum that pesticides should be used sparingly by refining methods of targeting the insect pest.

AP18 DOCUMENTATION OF THE BIOLOGICAL COMMUNITY OF POLISHING PONDS (SUTTON CONCEPT SEWAGE TREATMENT SYSTEM).

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The "Sutton Concept" method of municipal sewage treatment combines an extended aeration, mechanical plant upstream of a polishing/storage pond. Effluent from the secondary clarifier is discharged to the polishing pond for further treatment by chemical, physical and biological process. Waste sludge from the secondary clarifier is discharged to the polishing pond, avoiding the need for sludge storage and ongoing costs for sludge disposal. Typically, final effluent from Sutton Concept systems approaches tertiary quality and is characterized by high transparency and low solids and ammonia concentrations.

The purpose of this project is to document the biological community of the polishing pond component of the treatment works. Specifically, the phytoplankton and zooplankton communities will be documented on a seasonal basis. The role of pond fauna in maintaining high effluent transparency will be evaluated.

Results of this project will assist municipalities, consulting engineers and regulating authorities to assess the benefits and possible drawbacks of the Sutton Concept type of municipal sewage treatment. At this time, the Sutton Concept means of sewage treatment is being proposed for a number of smaller municipalities in the province.

The Sutton WPCP and the Tottenham WPCP have been selected for field studies. Both plants operate as Sutton Concept type systems and have continuous effluent discharge to the receiving stream.

BP18 PERFORMANCE REVIEW OF PERFORATED PIPE-GRASS SWALE STORMWATER DRAINAGE SYSTEM.

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The research, reported in this paper, addresses the Ministry of the Environment's research needs in the area of contaminants in stormwater runoff and the evaluation of groundwater recharge techniques.

The performance and potential of perforated pipes for stormwater quality control is evaluated. The study

design consists of a grass swale underlain by a section of perforated pipe enclosed in an exfiltration trench. The grass swale-perforated pipe system results in a pleasant curbless design and replaces the open ditch system, which performs poorly in winter-spring conditions.

Systematic analysis and assessment of the performance of grass swales used in combination with perforated pipes is conducted through inquiries with municipalities, literature surveys, and laboratory and field testing. The study shows that such systems, when feasible, result in reduced runoff quantity and hence pollutant loadings to receiving waters by infiltrating the first few centimeters of rainfall.

Few cities in Ontario used grass swale-perforated pipe systems and few design guidelines are presently available. Currently employed practices were determined by: a) an inquiry with consulting system designers and pipe manufacturers, b) monitoring the installation of a typical system, and c) a thorough review of recent literature. Hydraulic laboratory tests were undertaken to relate the exfiltration flow rate to flow depth in the pipe, pipe slope, surrounding soil characteristics, and perforation size and configuration. A field monitoring program was also conducted to gain a better understanding of the perforated pipe system performance under filed conditions. In this field program, stormwater quantity and quality was monitored for periods during and after storm events.

Based on results of the experimental program as well as field data a computer model is developed to serve as a tool for the design of grass swale-perforated pipe systems. Guidelines and recommendations on construction, maintenance and applicability are also provided.

If found to be suitable for local conditions, grass swale-perforated pipe systems would not only provide an adequate stormwater drainage system, but would also provide a cost effective best management practice (BMP) function for the management of stormwater quality.

AP19 BENTHIC INVERTEBRATES AS INDICATORS OF THE EFFICACY OF A HEAVY METAL COINTAMINANTS CLEANUP

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To date, the Brock University toxicology group has developed a test which utilizes the frequency of invertebrate (chironomid) abnormalities to assess the toxicity of contaminated sediments in rivers and lakes. Chironomids are representatives of a widely distributed group of aquatic invertebrate (insects) known as midges. Chironomid larvae were sampled and classified as either normal or deformed. A deformity was characterized by fused "teeth", crossed "teeth", extra "teeth", missing "teeth" (suggesting a weak mentum), or "teeth" of an extremely bizarre shape or size (Dickman et al. 1990). Among the 166 chironomids taken from the site in 1991 prior to its "cleanup", 7.2 % (12 chironomid larvae) possessed menta with deformities. Following the removal of the contaminated sediments by dredging at this site, 55 chironomids were sampled. The frequency of menta abnormalities in 1992 fell to 1.8% (n=1) .The McMaster Avenue storm sewer outfall pipe is located approximately 0.5 km upstream of the Atlas-Mansfield discharge pipe (Figure 1). The sediments at this site are contaminated with elevated levels of Cu, Cr, Fe, Mn and Ni (i.e. levels of these elements were in excess of MOE contaminated sediment criteria). Samples were taken at 10 m intervals across the width of the Welland River (circa 55 m) along a transect extending from Merritt Island on the western shore of the Welland River to River Road on the eastern shore of the Welland River. The transect was aligned with the outfall pipe of the McMaster Avenue storm sewer which is located approximately 0.5 km upstream of the Atlas-Mansfield Discharge pipe. Because the frequency of abnormalities dropped to less than that observed at the upstream (Evan St. "control" site, 3.8%) we speculated that sediments in the clean-up area had not been recontaminated with heavy metals from the adjoining wetland floodplain.

BP19 INDUCTION OF TOXICITY OF POLYCYCLIC AROMATIC HYDROCARBONS BY SUNLIGHT: PHOTOMODIFICATION OF THE CHEMICALS AND PREDICTIVE QSARs.

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Polycyclic aromatic hydrocarbons (PAHs) are a prevalent group of toxic and mutagenic environmental contaminants. Light increases PAH impacts through photosensitization reactions (e.g. generation of singlet oxygen) and by photooxidation of the chemicals. To examine the degree of involvement of the photomodified compounds in toxicity and the mechanism of PAH action in solar radiation, the photoinduced toxicity of six representative PAHs (anthracene, phenanthrene, benzo(a)pyrene, fluoranthene, pyrene and naphthalene) to the aquatic higher plant *Lemna gibba* L. G-3 was investigated. Toxicity endpoints were inhibition of growth, chlorosis and photosynthesis. The order of phytotoxic strength in simulated solar radiation (SSR) was anthracene > phenanthrene > pyrene > fluoranthene > naphthalene > benzo(a)pyrene. Both chemical concentration and light intensity influenced toxicity in dose dependant manners. The UV region of the solar spectrum was most active at inducing toxicity, showing that increases in UV-B due to depletion of the ozone layer could exacerbate the problem. To specifically explore whether photomodified PAHs contribute to toxic action, the chemicals were irradiated prior to application to the plants. The rates of photooxidation of the six PAHs were rapid on an environmental time scale and the relative velocities for five of the chemicals were coincident with the order of phytotoxic strength. Strikingly, the PAH photoproducts were much more toxic to *Lemna* than the parent compounds. In a similar line of experimentation, PAHs photooxidized in full, natural sunlight were found to have extremely fast rates of photooxidation (0.1 to 5 h). Furthermore, for some of the chemicals, after photooxidation in sunlight, the chemical concentrations required for acute toxicity were lower than for PAHs photomodified under laboratory lighting conditions. It is thus likely that photooxidized PAHs contribute to PAH hazards in natural environments. Since current environmental loads of PAHs are based entirely on the intact chemicals, the severity of the PAH impacts are very likely to be underestimated. To begin to alleviate this discrepancy, predictive quantitative structure activity relationships (QSARs) for the hazards of these chemicals in light are being developed. They are based on the photochemical properties of PAHs (photooxidation rates and the triplet-state life-times). These were found to correlate well with the empirical data on the toxicity of PAHs in SSR.

AP20 VALIDATION OF PULMONARY MUTAGENICITY AS AN INDEX OF PULMONARY CARCINOGENICITY.

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We have obtained some surprising results: (1) some carcinogens produce extensive chromosome damage but little or no mutation and (2) several carcinogens do not produce mutations in the lung fibroblasts *in vivo*. This does not reflect an absence of DNA damage, at least in some cases like methyl methane sulphonate (MMS), because many micronuclei can be observed in the cells. Could the lack of mutations in these cells be the result of the non-dividing nature of the fibroblasts *in vivo*? If non-dividing cells cannot be mutated by some agents, then the fibroblasts may be an improper model for the epithelial stem cells in which the carcinogenic mutations occur, although stem cells are probably non-dividing most of the time. Hence we have undertaken to test this idea with another assay in a tissue in which mutation of the stem cells can be detected and in which the stem cells are dividing.

The assay used was the dlb-1 locus assay in the small intestine. The presence of the dlbb allele can be detected by immunological staining, whereas the dlba allele results in a lack of staining. Thus in mice heterozygous for these alleles mutation from dlbb to dlba results in a ribbon of unstained cells running up the villus from the mutant stem cell. Acute treatments with MMS resulted in more ribbons but not significantly so. Ten weekly treatments with the same dose, however, produced a significant increase that was almost exactly 10 times that produced by the single treatment. This shows that the lung fibroblast result is essentially correct, but suggests that multiple treatments may increase the sensitivity of the assay. Thus there may be no agents that produce only chromosome aberrations and no specific locus mutations, a result with important implications for understanding the relation between mutagenicity and cancer and thus predicting from laboratory results which environmental agents are most hazardous to our population.

BP20 CONTINGENCY PLANNING FOR ACCIDENTALLY RELEASED GENETICALLY-ENGINEERED MICROORGANISMS (GEMs) IN THE ENVIRONMENT.

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Risks of releasing GEMs into the environment requires research on biological control and containment of microorganisms. Possible containment methods include chemical disinfection, destruction by burning and use of suicide plasmids that contain genes encoding cell

destruction, that may be induced by non-toxic chemicals such as lactose. Experiments were conducted to determine the effectiveness of seven chemical disinfectants against selected GEMs under optimal growth conditions. Each chemical was tested for the ability to kill 108 cells/ml Pseudomonas fluorescens strain C5t (engineered to contain the *Bacillus thuringiensis* endotoxin) in King's B broth at 30°C. Effective chemical treatments were calcium hypochlorite, benzalkonium chloride and commercially available Germiphene and Spectrum Clear Bath. Benzalkonium chloride and Germiphene killed 99.9% of the cells within 10 min at concentrations as low as 0.005% (v/v). Calcium hypochlorite killed 95% of the cells within 10 min at 0.05% (w/v). Spectrum Clear Bath killed 99% of the cells within 10 min at a concentration of 0.015% (v/v). These agents were also tested on Pseudomonas putida strain PaW340 (pLV1013) (engineered to express the xylE phenotype) in nutrient broth. All agents, except calcium hypochlorite killed over 99.9% of the cells within 10 min at the same concentrations required to kill strain C5t. The next stage in this research will determine effective concentrations of these chemicals to kill GEMs in soil microcosms under various conditions including temperature, inoculum concentration, presence of plants and the time between inoculation and disinfection. Additional GEMs that will be studied include P. fluorescens RNL11 (contains the lacZY phenotype), P. putida PaW8 (pLV1013) and *P. aeruginosa* UG2, a non-GEM biosurfactant producing strain. This research will provide information on potential control methods for GEMs.

AP21 MERCURY IN AQUATIC FOOD WEBS

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Recent studies in Canada, the USA, and Sweden have demonstrated that the mercury in lakes originates from atmospheric deposition (Fitzgerald and Watras 1989; Mierle 1990; Lindqvist, *et al.* 1991). Surprisingly, lakes which are located in the same geographic region and which receive similar areal inputs show significant between-lake variability in the fish mercury concentrations. Some of these differences can be explained by areal and substrate variability in the watersheds or by morphometric and physical-chemical differences within the lakes. Other differences appear to be due to food chain position (Lindqvist, *et al.* 1991) and prey switching during maturation (MacCrimmon et al. 1983). The objective of the Dorset Lakes Mercury Project is to quantify the relative importance of these factors by isolating the role that food web structure plays in determining methyl mercury pathways and pool sizes. Our approach is to characterize food web pathways and flux rates in lakes with very different piscivore communities. In 1991, we began work on four lakes comprising a non-replicated factorial design with respect to fish community structure and DOC concentrations. The data set that we are collecting includes: (1) the estimation of biomasses and genus or species compositions for the major components of; benthos, phytoplankton, zooplankton and fish, (2) the measurement of temporally stratified mercury concentrations in all major fish species, size structured zooplankton samples, phytoplankton samples and taxa specific benthic samples, (3) the estimation of rates of primary production and secondary production for zooplankton and fish (Downing and Rigler 1984, Ricker 1954) and (4) the estimation of flux rates for mercury and other elements using rates of zooplankton grazing (in-situ feeding experiments) and rates of food consumption by the major fish species (bioenergetics models). Our preliminary analysis of the relationship between food web structure and mercury pool size will be presented at Technology Transfer Conference.

BP21 RECEIVING WATER ENVIRONMENTAL EFFECTS ASSOCIATED WITH DISCHARGES FROM 10 ONTARIO PULP MILLS.

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Induction of hepatic mixed function oxygenase enzymes has been widely demonstrated downstream of bleached pulp mills, but there have been few studies in the biological responses of fish conducted on mills which do not use chlorine bleaching. Altered gonadal steroid production and regulation has been associated with many of the changes seen in the reproductive performance of white sucker and lake whitefish exposed to BKME, including delayed maturity, absence or reduction of secondary sexual characteristics, changes in egg size and reduced gonadal size. We examined the receiving areas of 10 Canadian pulp mills which discharged >50,000 m^3 day^{-1} of effluent, including kraft mills using chlorine, sulfite and TMP mills. Male white sucker were found to have induced levels of hepatic EROD activity, regardless of mill type, although those with chlorine bleaching showed higher induction. Females showed a more variable response, dependent upon receiving environment. Hepatic EROD activity in males was strongly correlated with effluent dilution, but not with AOX production data. Male activity also showed no correlation with dioxin levels within a site, but showed a clear relationship between sites. More than 90% of the TCDD TEQ's measured by the rat H4IIE assay could be explained by 2,3,7,8-TCDD and TCDF levels. Both sexes of fish showed depressions in levels of plasma sex steroids, impacts were observed at some sites without chlorine bleaching, and additional changes in liver size and gonadal size were easily detected. Preliminary conclusions of our studies are that a) induction of hepatic MFO enzymes and depression of plasma sex steroid

levels during early gonadal growth are a consistent finding downstream of pulp mills, b) most population level changes evident in wild fish can be correlated with decreased plasma levels of gonadal sex steroids, c) steroid problems are related to a breakdown in the control and production of gonadal sex steroids, and not directly to catalytic activity associated with induced MFO activity, d) secondary treatment does not eliminate these impacts, e) these impacts are seen at some mills without chlorine bleaching, f) dilutions of non-toxic effluent of >200:1 do not appear to remove these effects and g) laboratory toxicity tests on invertebrates and fathead minnow could not predict impacts on wild fish.

AP22 MUNICIPALITIES AND THE ENVIRONMENT IN SE ONTARIO, A FEASIBILITY STUDY BY QUEEN'S CENTRE FOR SUSTAINABLE DEVELOPMENT.

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1. A workshop to explore environmental decision-making by municipalities in SE Ontario was organized by the Centre in December 1991. Representatives of 22 municipalities, from seven counties, were addressed by Mr. C. Gosselin on environmental planning in the Regional Municipality of Waterloo. Group discussions were chaired by the multidisciplinary centre's representatives, and identified local issues, barriers to reaching sustainable policies in SE Ontario, and suggestions for improvements

Issues identified included waste management, sewage treatment, toxic contaminants, conservation of habitats and wildlife, and recreational use of land and water. Problems included fragmented jurisdiction, money, lack of information, inadequate discussions, confusion of responsibilities, conflicts of interest, powerlessness, lack of self-confidence and inadequate policy instruments.

Suggested actions included setting priorities, exchanging information between municipalities, educational activities, involvement of volunteers, introducing full cost accounting and making sure it is understood by the public, and obtaining fuller environmental inventories. A desire for further workshops was expressed. A 22 page report was circulated and copies are available.

2. A questionnaire designed to investigate municipal attitudes to the RAP in the Bay of Quinte was sent to 17 municipalities in the Quinte area in 1992. Less than 50% were returned despite phone calls. All counties and large towns responded; some municipalities on the shoreline did not. Preliminary analysis of results shows concern about the overall effects of RAP at the municipal level, and concern about information. Despite the excellent work of the PAC many municipalities were poorly informed on issues and processes in the RAP. A full report is being produced.

BP22 CHROMIUM SPECIES IN ONTARIO LAKES: CONCENTRATIONS AND CONTROLLING MECHANISMS.

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Large quantities of chromium are used in Ontario by industries involved in such processes as metal plating, leather tanning and lumber preserving. As a result, many lakes and rivers in the province are being contaminated with chromium, the typical concentrations being 2 to 50 parts per billion (ppb). This ambient concentration exceeds the water quality guideline of 2.5 ppb. This study was undertaken to examine the level of chromium contamination in Ontario lakes, as well as its forms and the biogeochemical controls on its distribution. An ion exchange system was modified to separate and preconcentrate the various redox species of chromium occurring in freshwater lakes. Conducted on board ship or on shore immediately after sample filtration, the method separates the three primary forms of dissolved chromium without disturbing the sample's equilibrium. The weak base anion exchange resin Sephadex DEAE A-25 was used to sorb the oxyanions of labile chromium 6+ and negatively charged dissolved organic matter containing bound chromium 3+, while excluding the positively charged labile chromium 3+ species. The first two species are eluted off the resin using a reductant and a strong acid respectively. All analysis were conducted on a graphite furnace atomic absorption spectrometer. The method is rapid and simple, quantifying the concentration of the known human carcinogen chromium 6+ in freshwater samples, as well as the less problematic chromium 3+ species. Preliminary results indicate approximate detection limits of 5 parts per trillion (ppt) labile chromium 6+, 10 ppt labile chromium 3+ and 50 ppt organically bound chromium 3+. During the summers of 1991 and 1992, Lake Ontario was sampled vertically through the water column in a number of locations. Surface samples were also collected from a number of smaller lakes. The species distribution results from these sampling episodes will be discussed in terms of possible controlling mechanisms such as redox chemistry, lake dynamics, trophic status and nutrient profiles.

AP23 SOURCE PROFILES OF EMISSIONS FROM RESIDENTIAL WOOD BURNING IN ONTARIO

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Emissions from residential wood burning have caused adverse air quality impacts in several areas in the United States and Europe. Several areas in the U.S. have implemented regulations ranging from mandatory

certification of woodburning stoves to restrictions on the use of wood stoves directed at minimising such impacts. Given the extensive use of woodstoves in some Ontario communities, the Ontario Ministry of the Environment undertook a study designed to characterize the organic and inorganic components in residential wood stove emissions from typical firewood and stoves used in Ontario, and to conduct of air monitoring studies in selected wood burning communities in Ontario. The source profiles of the emissions from wood stoves and wood species in common use in Ontario are reported here. The profiles will allow reliable estimates to be made of the contribution of woodstove emissions to ambient air quality in Ontario communities with several other air pollution sources.

Emissions from three wood stoves in common use in Ontario together with three wood types (jackpine, birch and maple) were sampled using the U.S. EPA Modified Method 5 protocol to measure 23 organic and 21 elemental species. The method included collection of particulate material on a glass fibre filter and vapour phase material on a backup XAD-2 sorbent. Three separate analyses of the sampling train material (front half of train and 1/2 filter extract, XAD-2 sorbent and back half of train, impinger solutions) by Gas Chromatography/Mass Selective Detection (GC/MSD) for organic components and a single analysis (1/2 filter only) by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICPAES) for inorganic species were conducted. Duplicate and in some cases triplicates tests of emissions from each of the nine wood type and stove combinations were conducted for a total of 20 valid tests. All but one (acridine) of the 23 organic species were found in all samples. Five of the 21 inorganic species were not detected in any sample and five other inorganic species were not detected in emissions from one stove type.

Source profiles were developed by taking the ratio of the measured concentrations of both organic and inorganic species to the concentration of benzo(e)pyrene (BeP) in each sample. The source profiles determined in this study (CONCORD profiles) are compared with literature data in terms of the similarity of the profiles and the variability of the profiles. Two profiles for the particulate fraction of woodstove emissions in a U.S. EPA database have similar ratios to BeP for 8 of 20 organic and 4 of 18 inorganic species. "Similar" profiles are defined as differing by less than a factor of 2 and "acceptable" uncertainty defined as a percent relative standard deviation (%RSD) of <50%. A composite of the CONCORD profiles showed similar ratios with both EPA profiles for 6 organic and 2 inorganic species. Since all species were not similar, the profiles can be regarded as distinct. The average %RSDs in the CONCORD profiles by stove type were 92%, 156% and 157% and by wood type 125%, 144% and 166%. The average percent relative standard deviation (%RSD) of the ratios for individual species ranged from 37% to 444% when all data were considered without regard for stove or wood type. The average %RSD for organic species (166%) was lower than that for inorganic species (256%). The uncertainties in the EPA profiles ranged from 0 to 650% for inorganic species and 0 to 150% for inorganic species. The uncertainties in the CONCORD and EPA profiles which have been used in several source apportionment studies are discussed bearing in mind the differences in sampling protocols. The CONCORD profiles are also considered acceptable for use in source apportionment studies. The suitability of the CONCORD profiles obtained in this study for source apportionment is discussed.

BP23 SUGAR MAPLE DECLINE AND CORRESPONDING CHEMICAL CHANGES IN MAJOR POLYMERS IN THE STEM TISSUE (CARBOHYDRATES, LIGNINS, AND TRACE ELEMENTS)

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Possible relationships of sugar maple decline and consequent chemical changes in sap and wood composition, which might correlate with the degree of decline were investigated. By comparing healthy trees with maples suffering various degrees of decline (using the Ministry of the Environment's physical decline index), a chemical index can be developed in relation to decline status. This index could be related to known indices of climatic, site, atmospheric and biological variables in a cause-effect manner and might become a useful diagnostic assay for "early warning" of decline syndrome in maple stands. Preliminary analysis of the wood samples show that aluminum is comparatively higher in the declining trees than in the healthy trees from the acidic sites. Additional results will be presented at the conference. Appropriate management strategies could then be implemented in a timely fashion.

AP24 CHURCH ROOFS AND SMELTERS: CAN WE MODEL SOIL CONTAMINANT MIGRATION?

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Ancient churches in Denmark have been depositing soluble lead in driplines for centuries. Similarly, all over the industrialized world, smelters and automobiles have been emitting particulates containing various metals, most notably lead (Pb), arsenic (As), cadmium (Cd) and antimony (Sb). Data from long-term contamination scenarios are invaluable for testing models of soil contaminant transport. Models, reliable in reproducing long-term accumulations in surface soils, give us confidence when applied to assessments of the disposal of both nuclear and non-nuclear wastes. The SCEMR1 (Soil Chemical Exchange and Migration of Radionuclides, Version 1) soil contaminant transport model, used in Canada's Nuclear Fuel Waste Management Program, has been tested on 800 years of Pb deposition from Danish church roofs. The model was

able to predict the observed accumulations of up to 11 600 mg/kg in the surface 24 cm of dripline soil. Distributions of Pb with depth can also be reproduced using SCEMR1. The redistribution of Pb following an historic addition of clean surface soil was also modelled. Predictions of surface soil Pb, As, Cd and Sb accumulations, using atmospheric dustfall data near Canadian smelters for periods of 20 years, show excellent agreement with measured soil concentrations. The SCEMR1 model has also been used to evaluate soil remediation at contaminated sites. Results show that the model can assess the long-term impact of partial removal of contaminated soil. Strategies such as additions of topsoil to bury contaminated soil can also be optimized using the model. The SCEMR1 model is particularly good at delineating the recontamination of surface soils due to the upward migration of soluble contaminants by capillary rise and evapotranspiration processes.

BP24 RESEARCH ON ULTRAVIOLET RADIATION MONITORING AND FORECASTING OVER SOUTHERN ONTARIO

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The current status of the ultraviolet radiation levels is important since the depletion of the ozone layer due to chlorofluorocarbons continues to increase. Ozone levels at midlatitudes in the northern hemisphere have declined by 6% over the last 12 years. The relationship between the ozone column and ultraviolet radiation (UVB) levels is important to most of the biology of the planet. Measurements of the UVB levels and the climatology of UVB over southern Ontario are shown. It is expected that the depletion of the ozone layer will continue to worsen and the UBV levels will increase over the next 20 years.

A measure of the effect of UVB radiation on humans is the SUNDEX sunburn time. In a pilot project in the summer of 1990, the SUNDEX was measured in the morning and transmitted to the media in the afternoon. This monitoring was continued in 1991 and 1992. In May, 1992 the UV levels were about 15% above the normal of the last 3 years. In summer, the levels returned to close to normal. The sunburn time is usually at a minimum about 17 minutes in late July and increases rapidly into fall until in winter it is over 4 hours. Research on the relationship between UV levels and cloud conditions is reported. The generation of the SUNDEX and UVB intensities from satellite ozone fields is discussed and demonstrated by example

AP25 *In situ* CHEMICAL OXIDATION OF CREOSOTE RESIDUALS.

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This research is evaluating the use of a strong oxidizing agent for the purpose of *in situ* remediation of creosote contaminated aquifers. Laboratory studies have been conducted to determine suitable oxidizing agents and their effectiveness in oxidizing representative creosote compounds. The oxidizing agents selected for laboratory studies were potassium permanganate, Fenton's reagent (H_2O_2, Fe^{2+}) and potassium persulfate with ferrous ions. Most oxidizing agents need harsher pH's and temperatures than what can be used in an aquifer environment. For example, Fenton's reagent is used at a pH of 1-2 to purify waste waters and permanganate is also used in acidic solutions to cause carbon-carbon bond cleavage in the oxidation process. Thus it is our goal to study the effectiveness of these oxidizing agents within the constraints of an aquifer environment. With the oxidation process we hope to achieve the mineralization of wastes or in the case of the larger, more refractory, less soluble constituents their break down to more soluble and biodegradable acids and alcohols. Also the oxidation process may cause polymerization to create non hazardous, non leaching material. The conditions for the oxidizing agents were optimized using p-cresol. To simulate aquifer conditions, the batch laboratory experiments were buffered to a pH of 7 and were conducted anaerobically, in an atmosphere of nitrogen. For Fenton's reagent we have found that the optimal initial ratio of organic:H_2O_2:Fe^{2+} was 1:34:8 and for the persulfate reaction the optimal initial ratio of organic:S_2O_8:Fe^{2+} was 1:10:8. Both reaction rates decreased after approximately 15 minutes independent of the initial reaction conditions. To complete the oxidation process additional catalyst (Fe^{2+}) needs to be added since the catalyst was not being regenerated. Permanganate was able to oxidize p-cresol readily in a one to one mole ratio of organic to $KMnO_4$. Using all three reagents, oxidation of indole has been successful and there has been limited success with the oxidation of 1-methylnaphthalene and pyrene at concentrations near their aqueous solubilities. The addition of aquifer water and sand to the batch laboratory experiments did not cause any significant change in the reactions rates. Currently laboratory experiments are investigating the oxidation of actual creosote with the three oxidizing agents and the use of permanganate with a phase transfer catalyst.

BP25 SOIL INGESTION: AN INADVERTENT BUT IMPORTANT PATHWAY.

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Soil ingestion has been shown as the most important pathway for certain contaminants to reach humans and other animals. It is important when the contaminants are sparingly soluble and essentially not present in water or vegetation. Soil ingestion happens inadvertently through ingestion of soiled vegetation and through hand contact, and purposefully in certain circumstances. We investigated the soil that adheres to skin, and found it to be up to tenfold more contaminated than the original soil, because of particle-size selection. We investigated bioavailability of contaminants on soil, through rodent feeding trials, and found the soil in the diet decreased the bioavailability twofold relative to a soil-free diet. Results indicate that several of the assumptions commonly used to estimate the impact of contaminants through soil ingestion are not accurate.

AP26 IMPACTS OF SOLAR RADIATION ON POLYCYCLIC AROMATIC HYDROCARBONS: PHOTOOXIDATION AND BIOAVAILABILITY.

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Polycyclic aromatic hydrocarbons (PAHs), compounds consisting of two or more fused benzene rings, are a prevalent group of toxic and mutagenic contaminants. They are ubiquitous in nature and because of their high degree of hydrophobicity tend to partition from air or water into the lipoprotein membranes of plants and other organisms. Indeed, PAHs have been detected throughout the plant kingdom primarily as a result of assimilation from the atmospheric and aquatic environments, and can be hazardous to plants. Interestingly, light (particularly UV radiation) has been shown to increase PAH toxicity, through both photosensitization reactions (production of singlet oxygen) and photomodification of the chemicals to new species. The most common mode of photomodification is oxidation to quinones, diols and carboxylic acids. Our work has shown that PAHs modified by solar radiation are much more toxic to plants than intact PAHs. We have thus begun to examine the kinetics and products of PAH photomodification, as well as assimilation of both the intact and altered chemicals in the presence of simulated sunlight. Products formed from PAHs after photomodification were analyzed by HPLC and GC-MSD. The results indicate a complex array of compounds are formed through the photomodification process; approximately 10 products from each PAH. The rates of photomodification of all the PAHs tested were rapid enough to be of environmental concern. Furthermore, the photomodification process increased the water solubility of the chemicals and was observed to drive release of PAHs from bound phases to the aqueous phase. Using the aquatic higher plant Lemna gibba, assimilation of the chemicals was also examined in the presence of light. Plants were incubated in growth medium containing ^{14}C-PAHs under simulated solar radiation (SSR) and darkness. Bioaccumulation was monitored by liquid scintillation counting of both the plants and the medium. In both the light and the dark, Lemna was found to have a high capacity for PAHs. Interestingly, assimilation in the light was generally less than in darkness, possibly because the photooxidized PAHs are less lipophilic than the intact chemicals. We also examined assimilation of PAHs from the bound phase (adsorbed to sand to mimic sediment). Uptake from sand was slower than directly from the medium. However, in this instance SSR hastened movement of the chemicals into the plant tissue, probably because the photooxidized compounds are more water soluble than the parent compounds, thus driving them from the soluble phase and increasing their contact with plants. We conclude that light can promote movement of xenobiotic compounds from bound phases to the biosphere.

BP26 DETERMINATION OF THE INTEGRITY OF SOLID WASTES BY LARGE SCALE LEACH COLUMNS UNDER ENVIRONMENTAL AND CONTROLLED CONDITIONS.

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The research from this project improves the understanding of leachate development from MSW landfills containing contaminants. Landfilling is most common method of disposal for municipal solid waste(MSW) and hazardous solid waste throughout the world. As a result of technological advances, the nature as well as the quantity of solid waste has changed dramatically over time. In spite of improvement in site selection, design, operation and maintenance of landfills, an improper disposal of varying quantities of hazardous materials from household waste may impose detrimental environmental consequences. These consequences include the contamination of groundwater due to mobilization of heavy metals such as Zn, Pb, Cd, etc from landfills. The chemico-physico-biological reactions occurring in a landfill are still not well understood. The main focus of this project was to develop an understanding of the effects of addition of hazardous solid waste with MSW on leachate behaviour. This study was carried out in simulated landfill columns packed with five different compositions of MSW and IW. This report marks the completion of the study of leachate from the columns which were in operation for 2300 days. Data collected for leachate analysis over the period of study has shown that the presence of hazardous waste has a positive influence on the concentrations of COD and all the

elements except water soluble elements such as Na, K, Cl and Br. The concentration data for COD and elements for MSW only columns fit well with a first order kinetics model while data for MSW + IW columns do not fit this model.

AP27 TRANSPORT OF DISSOLVED CONTAMINANTS IN THE VADOSE ZONE

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Dissolved contaminants, spilled on the ground surface, enter quickly into the relatively dry or partially saturated surficial soils. Whether the contaminant reaches the ground water table quickly or only in the longer term depends mainly on the type of surficial soil and the volume of the spill (or leakage rate and duration). Surficial clay soils are likely to be highly fractured and initial entry rates will depend on the degree, size and depth of the fracturing. In granular soils, hydraulic conductivity, porosity and volumetric water content will be the controlling factors. It is important to be able to estimate the extent of the immediate contamination and the extent to which delays in remediation might increase remediation costs or endanger mobilized ground water. Theoretical approaches to predicting the movement of a conservative dissolved contaminant in a partly saturated fine sand are hindered by the difficulties posed in the measurement of the controlling non-linear parameters. Theoretical advances can be supplemented by centrifuge modelling. Centrifuge modelling of a contaminant spill of 2000 l of a 10% solution of Sodium Chloride on the surface of a 6 m deep partly saturated fine sand was carried out at scale factors of 25 and 50. The distributions of the contaminant after two months, six months and one year of prototype times was found experimentally by dissection of the models. The results support the contention that centrifuge modelling does correctly recreate prototype transport phenomenon, including transport due to matrix suction, in partly saturated fine sand. For the conditions modelled, it was found that all of the contaminant introduced at the soil surface became immobilized, for at least one year, in the upper two to three meters of the six meter deep soil profile. Although it is possible to use centrifuge modelling to evaluate pollution risks in real variable soil profiles, the immediate important contribution of this modelling is to produce data sets which can be used to evaluate characteristics.

BP27 MICROBIOLOGICAL INDICATORS INDICATORS EOR ASSESSING HYDRAULIC CONNECTION IN BURIED HIGH PERMEABILITY ZONES AT WASTE DISPOSAL SITES.

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Ground water samples from selected sanitary landfills were analyzed for bacterial populations i.e. profiles of predominant heterotrophs, *E.coli* and *Salmonella*. In addition, lead and cadmium tolerant strains were identified as possible evidence of contamination. Using an ecological approach, ground water and leachate samples from hydro-stratigraphic units were tested for an array of biological, chemical and physical parameters. The data indicated that the populations from each landfill monitoring are distinctive and that nc viable *E.coli* or *Salmonella* were detected. Genetrak probes have not revealed *E. coli* or *Salmonella* sp. The populations of heterotrophic bacteria were unique within each monitoring sample. The organisms were typical of freshwater, stagnant water and soil. The chemical and hydrogeological tests are consistent with the biological findings, i.e. that the landfill-generated chemicals and bacteria are largely retained within the refuse. Bacteria which enter the site with the refuse - those associated with human household waste, do not survive in the ground water draining the mature refuse.

Isotopic studies of the ground water from the shallow wells indicated vertical and horizontal movement in shallow areas through fractures in soil at a site 1 km from the landfill. Ground water in this zone is 40 years old. In deeper wells, the isotopic studies show older water in the order of 10,000 years which clearly indicated no contact with the surface. The microbial populations are distinct in each deeper well based on the cluster analysis because the silt/clay overburden is preventing movement of ground water. Population studies designed to track bacteria through the landfill were enhanced by the use of cluster analysis and gene probes. Gene probe methods are being developed to detect non-cultivatable indicator strains.

AP28 GROUNDWATER CONTAMINATIN FROM A LARGE FLUX SEPTIC SYSTEM ON SAND

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A network of over 400 groundwater sampling points was installed in an unconfined sand aquifer to monitor the effects of a septic system servicing an elementary school in southern Ontario. The wastewater was very high in nitrogen (131 mg/L as NO_3-N), chloride (213.6 mg/L) and sodium (108.4 mg/L), and relatively low in dissolved organic carbon (15.9 mg/L) and phosphates (9.4 mg/L as PO_4-P). The only volatile organic com-

pound detected in the septic tank effluent was toluene at very low concentrations (0.05 ppb). The average ammonia concentration in the tank effluent (128 mg/L) is exceptionally high in comparison to most domestic sites examined. A bromide tracer test indicate an approximately eight day residence time in the 1.6 metre unsaturated zone beneath the tile bed. This was found to be sufficient to allow almost complete oxidation of the waste nitrogen and organic carbon, despite the high sewage loading.

An initial estimate of the extent and shape of the zone of the contamination extending form the tile bed was obtained using an EM31 ground conductivity tool. Elevated conductivity levels were observed downgradient from the tile bed which aided in the correct placement of the piezometer network. The plume, characterized by detectable dissolved oxygen, high nitrate (NO_3^--N from 120 to 20 mg/L), chloride (209-42 mg/L), sodium (101-34.1 mg/L), calcium (249-120 mg/L), sulphate, and potassium was delineated over a 100 metres distance from the tile bed. Elevated levels of phosphorus (1.8 to 0.3 mg/L PO_4^--P) were detected within the plume core for a distance of up to 60 metres form the tile bed, a much larger distance than at other sand aquifer sites studied in a similar manner. This may be due to the advanced age of this system, where the capacity to attenuate may be exhausted over time.

BP28 AN OVERVIEW OF TRACE METAL - SUSPENDED PARTICULATE REACTIONS IN THE DON RIVER: THE INFLUENCE OF SEDIMENT GEOCHEMISTRY; ENVIRONMENTAL VARIABLES; AND DISCHARGES TO THE SYSTEM

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Reductions of suspended solids and metals are important criteria in water quality remediation of the Toronto Area Watershed. We have determined trace metal associations with suspended particulate matter (SPM) in situ in the Don River over 4 years (1988 - 1991). In addition, we have geochemically partitioned SPM - metal associations from 3 outfalls to the Don. Partitioning among key particulate geochemical phases has been examined as sediment geochemistry plays an important role in determining the ultimate fate of a metal ion. Depending on which geochemical particulate fractions are involved (e.g. clays, organics, oxides), metals may be bound by particulate matter in the Don, only to be released again given changes in system chemistry once the River empties into Lake Ontario. We will give an overview of trace metal particulate reactions in the Don River, and provide results that highlight the following points: 1. patterns of geochemical partitioning emerge for Cd, Cu and Zn, *in situ* in the Don; 2. environmental variables such as Cl- (derived from road salt) and temperature influence partioning among dissolved and particulate fractions; and 3. geochemical partitioning of metal - particulate associations from specific outfalls show differences from those observed *in situ*.

AP29 DETERMINATION OF GEOCHEMICAL MODIFICATION OF GROUNDWATER ENTERING SURFACE WATERS FROM AN INDUSTRIAL AND A MUNICIPAL DISPOSAL SITE.

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This work is intended to provide a perspective on questions of groundwater and contaminant flux to surface waters, i.e. in what situations might "groundwater MISA" be appropriate?

Efforts to reduce surface-water pollution may require assessment of groundwater and contaminant flux. Although methods have been developed for locating and mapping areas of submerged seepage to surface waters, the quantitative impact of seepage is often difficult to determine. A biogeochemical transition zone can exist in the sediments through which groundwaters seep. As a result, samples of groundwater near a surface-water body may not be indicative of groundwater impact on that surface water. The objective of this work is to determine changes in water quality occurring as groundwater travels upward through lake or river sediment. A laboratory seepage facility was constructed to develop sampling techniques for field assessment and to determine quantitatively the chemical change that occurs where a physically-simulated groundwater passes through lake sediments. The groundwater contains nickel, cobalt, lithium, bromide, chloride, sulfate and nitrate. The sediments in this experiment are (1) sand without added organic matter, (2) sand with added organic matter and (3) deep-water, organic-rich mud. Both sulfate and nitrate are reduced during seepage through the organic-rich sediment, nitrate is reduced in the organic sand and neither nitrate nor sulfate are reduced in the clean sand. There appear to be significant accumulations of cobalt and nickel at the surface of the sandy sediment, perhaps associated with the iron oxyhydroxide accumulating there. Geochemical modelling is planned for the next 6 months.

BP29 ABSTRACT FLUCTUATING CONCENTRATIONS IN COMPLEX TERRAIN

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The objectives of this study were to compare short-term concentration fluctuations measured in the field to those measured in a wind tunnel simulation of the field conditions, to describe statistically the short-term fluctuation of concentrations measured both in the field

and in the wind tunnel, and to compare both field and wind tunnel concentration data with available numerical models for concentration fluctuation.

The field data used in the study were collected by the Ontario Ministry of the Environment's mobile Trace Atmospheric Gas Analyzer (TAGA) unit while on assignment in Cornwall, Ontario in 1986. The TAGA was deployed to monitor gaseous chlorine and chlorine dioxide in the vicinity of facilities operated by DOMTAR Fine Papers and Canadian Industries Limited (CIL). During the monitoring program, visible emissions were observed coming from a group of exhaust vents at the DOMTAR facility, and the TAGA team attempted to position the unit downwind of these vents, as close to the centre of the dispersing plume as possible. Concentration measurements with sample durations between 30 and 60 minutes were taken repeatedly over a three week period. During each sampling period, instantaneous concentration of chlorine and chlorine dioxide were recorded at 10 second intervals. Wind speed, wind direction (as measured at 10m above grade at the TAGA location) and temperature were also recorded, at 30 second intervals.

Eight of the TAGA sampling periods were selected and individually reproduced on a scale model of the DOMTAR/CIL study area, in a boundary-layer wind tunnel. In each case, wind velocity tests were conducted to ensure that the local wind conditions were properly simulated. The characteristics of the chlorine gas releases at the DOMTAR facility were then simulated as closely as possible, and concentrations were measured at the scale model TAGA position. The chlorine releases were simulated using a mixture of propane and air, and the concentrations were measured using a fast-response FID (Flame Ionization Detector). The resulting mean and fluctuating components of the measured concentrations were compared to the corresponding full scale TAGA data.

The eight selected TAGA sampling cases were also simulated using selected combinations of available numerical models for the mean and fluctuating concentrations. The selection of the numerical model combinations was based on a brief literature review of available models. The results were compared to the scale model and full scale data.

The study results gave a preliminary indication of the ability of wind tunnel and numerical models to predict fluctuating concentrations in built up terrain. Various numerical models for the mean and fluctuating components of concentration were reviewed, and three modelling combinations were selected for use in this study. Huber's model for mean centreline concentration in the wake of a rectangular building, combined with Wilson's model for concentration variance performed best overall among the numerical models and, in most cases, performed equally well in comparison to the wind tunnel simulation.

Mean, rms (i.e. standard deviation), 90th percentile and 95th percentile concentrations were, in most cases, predicted to within 50% of full scale, by both the Huber/Wilson numerical model and the wind tunnel simulation. These results are promising in terms of the potential for predicting fluctuating concentrations, especially in light of the uncertainties associated with the full scale data (i.e., pollutant emission rates, exact TAGA position, reference wind conditions). The peak-to-mean ratios had one less source of uncertainty (i.e., they were independent of the full scale pollution emission rates), and were generally predicted by the wind tunnel and numerical model to within 25% of the full scale values.

The measured and predicted 90th, 95th and 99th percentile peak-to-mean ratios at locations relatively close to the lateral plume centreline had upper limit values of 3.22, 4.29, and 6.63, respectively. Values measured in the wind tunnel at locations somewhat further away from the centreline were higher. The 99th percentile peak-to-mean ratio, for example, went as high as 13.5.

The Huber/Wilson numerical model is applicable to locations along the lateral centreline of a dispersing plume. As a result, it tended to overestimate the full scale mean concentrations measured by the TAGA which, in all likelihood, was seldom directly on the plume centreline. At one particular measurement location, the mean concentration predicted by the numerical model was a factor of 10 higher than that measured by the TAGA, whereas the wind tunnel result was within 10% of the TAGA value. In addition to being off the centreline, this location B was also in a region of recirculating flow in the near wake of a building. There were two cases where the numerical model underpredicted the mean concentrations, and these results were probably related to uncertainties in the full scale data and to local dispersion effects produced by the complex building geometry. The results for these cases and for Location B underscore the relative simplicity of the numerical models that are currently available for predicting concentrations in the wake regions of buildings.

The fluctuating concentrations measured on the scale model were very sensitive to the exact position of the FID probe and the precise setting of the reference wind direction. Since the full scale TAGA position and reference wind direction were not known to a high degree of precision, there was leeway to make small adjustments to these parameters on the scale model, within the range of uncertainty, in an effort to improve the simulation results. Some adjustments were made, but it is likely that further tweaking of the simulation would have led to even better agreement with the full scale data than was obtained.

For the best simulation, precise information on the source emission rates, TAGA position and reference wind conditions are needed. While source emissions data may be difficult to obtain in many cases, accurate recording of the TAGA position and reference wind conditions should be feasible. The reference wind conditions are, in most cases, an important determinant of the pollutant dispersion. When the TAGA is positioned in the near wake of a structure, tree belt or other obstruction, the wind parameters measured by the TAGA unit will be indicative of local wake effects. In such a case, it will be difficult to make inferences about the references wind conditions in the open. The wind information recorded by the TAGA might be more useful if the wind instrument were left in a nearby open area

while the TAGA is moved to the desired position for concentration measurements.

With improved documentation of the field conditions, the combination of TAGA concentration data with wind tunnel simulation data or, in some cases, numerical model data represents a powerful tool for investigating air pollution events, particularly for odorous pollutants or other cases where the concentration fluctuations are of concern. While the TAGA provides a direct measurement of pollutant concentration, the suspected source of the pollutant could be confirmed by simulating its emissions and obtaining concentration results that are consistent with the TAGA measurements.

AP30 FATE OF CONTAMINANTS IN MUNICIPAL POLLUTION CONTROL PLANTS

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A major issue facing the Ministry is that of ensuring improved treatment of domestic and industrial sewage for the removal of toxic and persistent organic substances. These substances vary greatly in properties, thus they are subject to different treatabilities, being variously discharged in the air, sludge, effluent, and degraded during treatment. It is important to understand and predict these treatability characteristics as a function of the properties of the chemical and the design and operating characteristics of the plant. In this project, a computer model has been developed in order to calculate the fate of hazardous compounds in municipal water pollution control plants. The input parameters of the computer model are the physical properties of the chemical (molecular weight, vapour pressure, solubility in water, octanol-water partition coefficient, and biodegration rate constant) and the relevant volumes, areas and operating parameters of the biological wastewater treatment plant such as water flow rates, solids content in process streams and in reactors. The program, which is written in Visual Basic and is user friendly, solves the linear mass balance equation written around each vessel, which include expressions for partitioning of the chemical between air, water, and biomass, and transport by flow and evaporation and transformation by biodegradation in biomass phase. The output of the removal mechanism, volatilization, stripping, biodegradation, sludge washing and outflow in the effluent.

BP30 THE IMPORTANCE OF FUNDAMENTAL KINETICS AND MECHANISM STUDIES IN UNDERSTANDING PHOTODEGRADATION PROCESSES - AN OVERVIEW

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Photodegradation processes involve the use of intense UV lamps to remove and destroy organic pollutants from wastewaters. It is important to understand the mechanisms and kinetics of these processes so that they can be made more effective and efficient.

Over the past three years we have conducted a research program at The University of Western Ontario aimed at providing some insight into the kinetics and mechanism of photodegradation processes. Our studies fall into three broad areas of approach:

1. The sequence of photodegradation reactions: We have used the flash photolysis technique with detection by HPLC or GC to examine the reaction sequence in the photodegradation of 4-chlorophenol with and without the presence of hydrogen peroxide. We have also looked at the photolysis of n-nitrosodimethylamine with and without the presence of hydrogen peroxide. In some cases, we have been able to determine the quantum yield under environmentally meaningful conditions.
2. Rate constants for reaction of hydroxyl radicals and hydrated electrons with organic pollutants: These rate constants are largely unknown for most common organic pollutants. We have developed a method, based on the trapping of these radicals by a spin trap and detection by electron paramagnetic resonance spectroscopy, to determine many of these important rate constants.
3. Mechanism of photodegradation processes on TiO_2: Again using the technique of spin trapping with electron paramagnetic resonance detection of the spin adducts, we have examined the mechanism of the important radical reactions taking place on the surface of TiO_2 particles.

AP31 FATE OF VOLATILE ORGANIC COMPOUNDS IN WASTEWATER COLLECTION SYSTEMS

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Volatile organic compounds (VOCs) are organic chemicals that have an affinity for the gas phase and that can easily volatilize from water to air upon contact with an air-water interface. They are used in a wide variety of applications ranging from household cleaners to fuel additives, and commercial and industrial solvents. They are subsequently discharged to municipal wastewater collection systems (WCS) from a large number of sources including commercial enterprises,

industries, public institutions, and residential households.

This study will address the fundamental mechanisms which affect the fate of VOCs in WCS. Major objectives of the research include 1) estimation of VOC emissions from three industrialized collection reaches in Metropolitan Toronto, 2) determination of gas-liquid mass transfer coefficients and subsequent model evaluation based on field experiments in operating sewers in Guelph, 3) determination of the potential for VOC degradation by suspended and attached (to sewer walls) microorganisms in sewers, and 4) development of a multi-reach model to predict the ultimate fate of VOCs in complex sewer systems, with future applications in the development of sewer-use (discharge) regulations. Although significant progress has been made toward achieving each objective, only the first two are described in this paper.

BP31 REGIONALIZATION OF LOW FLOW CHARACTERISTICS IN THE NORTHEASTERN AND NORTHWESTERN REGIONS.

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A knowledge of low flow conditions is of prime importance for many watercourses when undertaking instream pollutant analyses, design of systems for low flow augmentation, environmental investigations such as stream fisheries assessment, and water supply and evaluation for water taking permits, etc. The identification of suitable low flow characteristics within a watershed is most easily accomplished where a historical record of continuous hydrometric data is available for locations along the stream. However, this is limited to the availability of suitable discharge records near the location of interest. The objective of this investigation is to develop a practically oriented technique for estimating low flow characteristics at ungauged locations for watersheds in Northern Ontario.

The initial statistical analysis included a comparison of the Gumbel III extreme value distribution and the Weibull distribution; including an evaluation of the utility of the newly developed L-MOMENTS technique for parameter estimation. A regional homogeneity test recently developed for the three parameter Weibull distribution (not previously used in Ontario) was then applied in an attempt to develop statistical sub-regions.

The interim results of these ongoing investigations have indicated that the available low flow database includes several stations exhibiting trend. The trend analysis included the Spearman's Rho test and the Mann and Kendall non-parametric test for trend in addition to application of a robust locally weighted regression smooth technique. The ongoing investigations will attempt to confirm or explain the low flow trend components identified.

The development of regionalization procedures for selected low flow characteristics (eg. 7Q20) is proceeding by evaluation of alternative techniques, namely: i) Mapped Isolines (with assistance of GIS technology); ii) Index Methods; iii) Regression Methods; iv) Station Pro-Ration Method. A representative sample of test stations was set aside from the available database in order to compare the accuracy of the predictive techniques developed to the results of single station statistical analyses. This will provide some measure of the predictive efficiency of the various methods.

Requirements for additional research will be identified including a further analysis of possible reasons for trend components in the available low flow data set, and further refinement of the regional prediction techniques.

AP32 NITRATE PERSISTENCE IN SLIGHTLY PERMEABLE SEDIMENTS IN ONTARIO.

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Although it is now recognized that NO_3^- contamination of shallow groundwater in southern Ontario has become widespread, NO_3^- levels in most deeper aquifers used for water supply remain relatively low. In many cases, the deeper aquifers are separated from the shallow contaminated zones by confining layers of slightly permeable lacustrine sediments or till. Thus, the long-term viability of the deeper aquifers may depend on the ability of the lower permeability sediments to attenuate NO_3^- during downward migration of groundwater from the shallow zones.

To address the possibility of NO_3^- attenuation, field investigations have been initiated at five sites in southern Ontario, where NO_3^- contaminated shallow groundwater is moving downward through slightly permeable sediment. At each site, a continuous undisturbed sediment core has been retrieved to 6-10 m depth and a multiple piezometer nest has been installed. Pore waters extracted from the cores by squeezing and immiscible displacement techniques have been analyzed for major ion content (NO_3^-, Cl^-, SO_4^{2-}, NH^{4+}) and tritium (^3H) content to establish groundwater age. The piezometers provide additional pore water samples and allow measurements of hydraulic head to confirm groundwater flow direction.

The sediment cores have also been used to establish solid phase properties (grain size distribution, carbonate content) and content of trace constituents such as soil organic carbon and reduced sulphur compounds that can promote NO_3^- attenuation by acting as electron donors for denitrification.

At locations where NO_3^- attenuation is observed, NO_3^- isotopic composition will be profiled to assess the usefulness of NO_3^--^{15}N and NO_3^--^{18}O as indicator parameters for denitrification in these environments.

The main period of data acquisition will occur in 1992.

BP32 GUELPH DRAINABLE WATER QUALITY MANAGEMENT MODEL

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A drainable water quality management model has been developed by adding a snowmelt component to the DRIANMOD model for simulation of rainfall-snowmelt-runoff hydrologic processes, under fluctuating watertable, applicable to Ontario conditions. The model has been tested for two locations in different agrometeorologic zones of Ontario. The model can be effectively applied to manage the fluctuation watertable induced by precipitation and subirrigation processes on a continuous basis. The model produces two hydrologic pass files i.e., one coupling the model to CREAMS on a storm by storm basis and the other for coupling with GLEAMS on a daily basis. The coupled model(s) is/are expected to be widely used for watershed planning to simulate the manage erosion/sediment, and the transport of nutrient and pesticide under fluctuating watertable conditions induced by subsurface/tile drainage.

AP33 MODELLING THE INFLUENCE OF TOPOGRAPHY ON DENSE GAS DISPERSION

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Topography, in the form of general slope, isolated hills, or more complex terrain, will alter or divert a dense gas cloud or plume. The topography may enhance plume dilution and divert the plume away from regions of elevated terrain; or, the dense plume may be channelled into valleys or low-lying areas and then be protected from the diluting influence of the ambient flow. These important effects are not included in the models currently used to predict the dispersion of a dense gas cloud for risk assessment or emergency management.

The overall objective of the study is the development of methods for incorporating the effects of topography in numerical models of dense gas dispersion. Phase I of the project consisted of an extensive review of the existing theory and experimental results applicable to the problem. Phase II of the project consisted of the development of algorithms for incorporating the effect of topography into integral (box) models of dense gas dispersion. This paper outlines the implementation and verification of the algorithms, based on the previous review and development.

Previous publications from this project have shown that it is possible to incorporate the effects of topography on dense gas dispersion within the box model formulation. These results have shown that these effects can be represented principally by: a modified advection velocity; and, a modified entrainment relationship. The treatment of other subsidiary aspects of the problem which are also necessary to provide a practical implementation of these ideas is outlined.

Preliminary results have been obtained using these algorithms in the GASTAR dense gas dispersion model. Figure 1 shows results for an instantaneous release similar to the Thorney Island trial 15 with no slope, and for upslope and down slope winds on a 5° slope. The radius and the concentrations are plotted as functions of the location of the cloud centroid. The upslope wind increased the radius of the cloud relative to the no slope case and the downslope wind decreased the radius. The concentration was increased relative to the no slope case for a downslope wind and decreased for an upslope wind. Figure 2 shows the results for a release similar to a Thorney Island test on a slope of 10° with the wind at 45° to the slope.

The results of the first two phases of this project have clearly indicated that the dominant effects of topography can be incorporated within the box model formulation of dense gas dispersion. Preliminary results have shown good agreement between box model predictions using the GASTAR dense gas dispersion model and experimental results.

BP33 KINETICS OF SULFITE OXIDATION IN THE PRESENCE OF AIRBORNE PARTICULATES

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The kinetics of the aqueous conversion of sulfite to sulfate have been studied using ion chromatography. This approach allows a large number of samples to be examined in a relatively short time. The results are indicative of the probable chemistry of the parent air mass, in addition the presence of exotic catalysts can be inferred when more common catalytic agents can not be identified. The technique can be used in conjunction with a suitable data base to identify air masses which are likely to pose significant health problems.

The work provides a means of monitoring air quality and as a means of alerting investigators to the presence of air toxics.

AP34 LIFE HISTORY AND DEMOGRAPHICS OF ZEBRA MUSSEL (*DREISSENA POLYMORPHA*) POPULATIONS IN LAKE ST. CLAIR, LAKE ERIE AND LAKE ONTARIO.

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The life history and demographics of zebra mussel populations from Lake St. Clair, Lake Erie and Lake Ontario have been studied and while the life history of

Dreissena polymorpha is similar in many lakes, variations are common. Adult zebra mussels from the Puce area of Lake St. Clair have a life span of about 1 - 2 years and rapid growth rates of over 1.0 cm per year. Maximum shell lengths average around 1.5 - 2.0 cm, with standing crops ranging from a low of 695 m^{-2} to just under 300,000 m^{-2}. Preliminary data from Port Stanley, in Lake Erie, suggest this zebra mussel population has a smaller maximum shell length and growth rates as compared to Puce. However, there is a ten fold increase in the standing crops which range from a low of 74,419 m^{-2} to over 2,000,000 m^{-2} at Port Stanley. Zebra mussels from the Lake Ontario site at Niagara-on-the-Lake only appeared in early September 1990, with a growth rate of approximately 1 - 1.5 cm over 5 weeks. Maximum shell lengths average around 1 - 1.3 cm, with standing crops increasing from 432 m^{-2} in early September 1990 to about 5000 m^{-2} by early October. The 1990 veliger data show similar trends for all three sites. At Puce veligers were first observed June 20 at a water temperature of 21°C and abundance peaked the first week of July at 162,000 m^{-3} and disappeared from the water by mid October. At Port Stanley veligers were first observed July 17 at a water temperature of 20°C and abundance peaked the beginning of August at 941,000 m^{-3} and disappeared from the water by the end of November. At Niagara-on-the-Lake veligers were first observed July 18 at a water temperature of 21°C and abundance peaked in mid September at 2920 m^{-3} and disappeared from the water by early October. Port Stanley and Niagara-on-the-Lake sites had two peaks in veliger abundance in 1990 but Puce had only one, although two peaks occurred in 1989. Within all three lakes there are annual variations in the time of first appearance of larvae, number of peaks per year, abundance, settling periods and gonad development.

BP34 EFFECTS OF VARIOUS HANDLING PROCEDURES ON RESPONSES OF ZEBRA MUSSELS (Dreissena polymorpha) IN BIOASSAY TESTING

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A series of bioassays were conducted to determine if a variety of factors influence survival of adult zebra mussels in bioassays. Mussels collected from Lake St. Clair were more tolerant to hypochlorite during early and late summer (10-d LC50 ranged 0.8-2.1 mg/L), and more sensitive during mid summer (LC50 ranged 0.3-0.5 mg/L). Fed and starved mussels maintained in the laboratory for up to 88 days had similar responses when treated with hypochlorite. After 88 days, fed mussels treated with bayluscide were more tolerant (96-h LC50 = 0.035 mg/L) than starved mussels (LC50 = 0.029 mg/L). When treated with hypochlorite, there were no differences in the tolerances of mussels from different locations, however, when treated with bayluscide, tolerances among stocks were significantly different, with population tolerances ranked Hamilton Harbour > Lake St. Clair > Lake Erie > St. Lawrence River > Lake Huron. Variation in mussel size among sites confounded the ability to determine if population differences or similarities are due to size or stock location.

BP35 THE IMPACT OF ZEBRA MUSSELS (*DREISSENA POLYMORPHA*) ON POPULATIONS OF UNIONIDAE IN LAKE ST. CLAIR AND THEIR EFFECT ON THE HOST UNIONID'S FILTRATION ACTIVITY AND GROWTH RATE.

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The impact of the zebra mussel (*Dreissena polymorpha*) on the Unionidae of Lake St. Clair was investigated from 1989 to 1992. During this time the density and diversity of the unionid population was surveyed at two sites in Lake St. Clair, Puce, Ont. and Grosse Pointe Farms, Michigan. Large increases in the average number of zebra mussels attached to a unionid's shell correspond to a significant decline in the density of unionid population at the Puce site, from 3/m^2 in 1990 to 0.05 unionid/m^2 in 1991, and a decline in diversity from 11 living species in 1990 to 3 living species in 1991. At Grosse Pointe Farms there was an average of 2 living unionids/m^2 in 1991, which was not significantly different from a 1986 survey (Nalepa, 1988). As of July 1992 the density of the unionid population was similar to the 1986 survey. The density and diversity of the unionid population at the Grosse Pointe Farms site had not declined as of July 1992 despite a significant increase in the number of attached zebra mussels from 17/unionid in June 1991 to over 300/unionid in Sept 1991. However the density of zebra mussels on unionids at Grosse Pointe Farms is significantly less than at the Puce site in 1990. Massive infestations of up to 2000 zebra mussels per unionid usually result in total occlusion of the unionid's siphonal region. To determine if these attached zebra mussels interfere with the food acquisition of the unionid the clearance rates of infested and uninfested unionids were compared. The results suggest that the position of the attached zebra mussels on the unionid's shell is an important factor in determining if the zebra mussels are interfering with the filtration activities of the host unionid. Zebra mussels attached to the siphonal area block the siphons of the unionid and physicaly interfere with the siphoning activities of the unionid. The effect of attached zebra mussels on the growth rate of their unionid host is presently being determined.

AP36 ZEBRA MUSSEL CONTROL METHODS FOR SMALL WATER USERS

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The recent discovery that zebra mussels (*Dreissena polymorpha*) had invaded some of Ontario's inland lakes, the Kawarthas and Muskokas, has caused wide spread fear and uncertainty for many small water users on those water bodies.

Although there has been substantial effort and revenue injected into research for zebra mussel control strategies for industry in the years since their introduction into the Great Lakes, little has been focused on control strategies for small water users on inland lake systems. To alleviate uncertainty for the small water user a control strategy must be found before zebra mussels colonize these lakes to the degree that has been witnessed on some of the larger lakes such as Erie and Lake St. Clair.

A non-chemical approach to this problem is preferred. The effectiveness of chlorine and other oxidants for zebra mussel control on an industrial scale is well documented however this strategy would not be wise or even feasible for most small water users for a number of reasons. Wide spread use of chlorine, by inexperienced individuals, on intake systems in these smaller inland lakes would be difficult to control and monitor and could lead to serious environmental damage should a spill occur. In addition, it would not be cost effective for the average small water user to install and run a chlorination/de-chlorination system for zebra mussel control. Lastly, the Ontario Ministry of the Environment has made it clear that chlorine should only be viewed as a short term solution and that alternative, preferably non-chemical strategies should be investigated.

Already many unproven products have been sold to an uneducated public through the use of scare tactics and media hype.

Presently, there are a number of products on the market which claim to prevent or inhibit zebra mussel colonization of water intake systems. These products may or may not have been properly tested by the manufacturer therefore there is a need for comprehensive, unbiased testing of those products which show some promise, for implementation in small intake systems, to properly develop this new technology.

Aquatic Sciences is presently actively involved in the research and development of non-chemical control strategies for zebra mussel infestation. Our present and ongoing activities include *in-situ* studies using heat, acoustics, cathodic protection, ultraviolet radiation, and disposable substrates.

This project involved the installation of ten proposed new zebra mussel control products for use by small water users (ie. cottages) in inland lakes. Each product was operated in a way to simulate some user intakes along side control intakes operated in a similar fashion. Products included multimedia filters, cartridge filters, water softening devices and magnetic devices.

At the time of this writing, all products were letting zebra mussel larvae through, however, analysis of settling data in downstream piping was not complete.

BP36 A LONG RANGE TRANSPORT MODEL WITH A NESTED FINE RESOLUTION GRID

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The nested grid mesoscale modelling system developed in 1990 - 1991 and presented at the Technology Transfer Conference in 1991, has been significantly improved. The system combines two separate models: a meteorological mesoscale model, Gesima, and the mesoscale version of the long range transport model, ADOM. The domain of simulation has been enlarged to 750 x 600 km and covers most of the Southern Ontario. The model simulates the transport, chemical transformation and deposition of a wide range of atmospheric pollutants with horizontal resolution of 20 km. It can thus detect effects of local emissions and local topographical features which are impossible to simulate with large scale models like the original version of ADOM.

The results of the simulation of a high ozone episode over Southern Ontario in August 1988 are described. The results show a substantial improvement over those obtained with the early version of the model and good agreement with observations obtained at several monitoring locations.

AP37 STUDIES OF OXIDANT FORMATION IN RURAL AREAS OF ONTARIO.

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The aim of this project is to use field measurements and explicit chemical modelling, to better understand the atmospheric oxidant chemistry occurring in rural Ontario. Previous studies have shown the importance of naturally produced hydrocarbons in ozone production. However, the ability to test the current understanding of this chemistry is limited by the inability to measure the concentrations of a number of the key compounds involved in the oxidation. In the first phase of this project we have developed techniques to measure the concentrations of a number of species that will give better insight into the importance of natural hydrocarbon oxidation.

Radicals are the primary oxidants in the atmosphere. Since they are very reactive, and have very short lifetimes, their concentrations are very dependent on the extent of the local photochemistry. Thus a measurement of radical concentration could be used to differentiate between locally produced oxidation products and those transported from elsewhere. We have developed an

instrument capable of measuring the total radical concentration, which was used in the recent Hastings Oxidant Field Study.

To look directly at the consequences of natural hydrocarbon oxidation we have developed techniques to measure the concentrations of two classes of oxidation products, carbonyls and organic nitrates.

We have extended our DNPH cartridge technique for carbonyl measurements to two products of isoprene oxidation, namely methacrolein and methyl vinyl ketone. In addition, we are now able to detect a wide range of mult-functional organic nitrates. These compounds are produced by the reaction of peroxyradicals with NO. Identifying organic nitrates in ambient samples indicates the radicals present which in turn points to the hydrocarbons undergoing oxidation. Both techniques were used in the Hastings Oxidant Field Study.

With these new tools, a better understanding of oxidant processes in the Ontario atmosphere should be realized.

BP37 REGIONAL SCALE TRANSPORT OF VOLATILE ORGANIC COMPOUNDS IN THE SUBSURFACE.

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There is considerable concern about the fate and transport of Volatile Organic Compounds (VOC's) in the subsurface environment. Due to their toxicity at often extremely low concentrations, the remediation of VOC's in the subsurface is an unavoidable and very expensive task. Numerical models can be used to design, test, and optimize remedial schemes before an extensive field program is initiated. This study develops an efficient methodology for simulating the transport of VOC's in two-dimensional cross-sections at the scale (up to thousands of meters in the horizontal direction) typical of field sites in Southwestern Ontario. A finite element model describing the two-phase flow of air and water in the unsaturated and saturated zone has been developed. The efficient and accurate Method of Characteristics technique has been applied to contaminant transport in the vapour and water phase. Dissolution, volatilization, and inter-phase partitioning are represented by the first-order mass-transfer equation. The analysis investigates the influence of ground cover, seasonal fluctuations in water table levels, and infiltration rates. Whereas most vapour transport models neglect water flow, this work displays the implications of vapour transport on long-term groundwater contamination and correspondingly, groundwater contamination on vapour transport. The model is used to analyze engineered remediation techniques such as soil venting and soil flushing at a typical Southwestern Ontario site.

AP38 REMOTE DETECTION OF HYDROCARBON FUEL CONTAMINANTS IN THE SUBSURFACE.

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The remediation of sites contaminated by hydrocarbon fuels requires a knowledge of the distribution of these contaminants in the subsurface. Although claims have been made that geophysical methods can, in some cases, map the distribution of hydrocarbon fuels in the subsurface, there is some scepticism among many geophysicists and hydrogeologists about the effectiveness of these techniques and their general applicability. To address this issue, and to improve the interpretation of survey data acquired with these techniques, we are performing field geophysical measurements in a test cell containing sand contaminated with kerosine, and laboratory measurements on the electrical properties of soil/air/water/kerosine mixtures.

A large cylindrical test cell (3.6m diameter by 1.7m deep), packed with sand and instrumented with monitoring devices, has been built to contain the kerosine spill. The multi-level monitoring devices within the cell are used to measure the induced changes in dielectric permittivity and resistivity. A geophysical access tube has been installed to permit the use of geophysical logging tools. A borehole video camera lowered inside glass observation wells is used to monitor the development of the kerosine pool above the water saturated zone. Ground penetrating radar (GPR) and EM induction surveys will also be performed at the surface. The water table will be maintained 1 m below the cell surface. During and following the injection of kerosine (500 litres) the changes in geophysical response will be monitored at the surface and *in situ* devices will monitor the induced changes in physical properties within the cell.

The results of these laboratory and field geophysical measurements will lead to a more effective application of these geophysical techniques to contaminant mapping problems.

BP38 EVALUATION OF A *STREPTOCOCCUS FAECIUM* SUBSP. *CASSELIFLAVUS* MODEL TO ASSESS POLLUTION SOURCES AT THE KELSO CONSERVATION AREA.

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Streptococcus faecium subsp. *casseliflavus* (now called *Enterococcus casseliflavus*) has been recovered from animal feces in densities approximating *Escherichia coli*. The organism could not be isolated from human fecal samples except under unusual circumstances. The best medium for recovery of the organism was found to be m-Enterococcus agar without the addition of 2,3,5-

triphenyl tetrazolium chloride.

To investigate whether *E. coli: E. casseliflavus* ratios could be used to establish human or animal pollution sources, nine sites along Sixteen Mile Creek were monitored in 1991 and 1992. The results showed that the average *E. coli: E. casseliflavus* ratio was 10.6 in an area of undisturbed mature forest with wildlife input. In comparison, an average ratio of 349.4 was obtained near the outflow pipe of the Milton Sewage Treatment Plant. Only one of 10 samples collected near the treatment plant yielded *E. casseliflavus* and this isolation was believed to be due to the impact of birds at the time of collection.

The results of this survey support the premise that *E. casseliflavus* is a reliable indicator of animal pollution. Further field studies to establish *E. coli: E. casseliflavus* ratio guidelines for the differentiation of human and animal pollution sources are warranted.

AP39 THE USE OF BODY-RESIDUE BASED MODELLING FOR ESTIMATING THE TOXICITY OF TOXICANT MIXTURES TO FISH

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Traditionally, the toxicity of chemicals to aquatic organisms has largely been investigated in terms of individual toxicants. Industrial effluent, contaminated surface waters and leachates, however, generally contain mixtures of toxic compounds. A general lack of understanding and inadequate predictive methods of toxicant interactions have made it difficult for regulatory agencies to provide water quality guidelines that effectively deal with toxicant mixtures. We are examining a whole-body-residue based first-order kinetic model for dealing with the combined effects of toxicants on aquatic systems. Juvenile fathead minnows (*Pimephales promelas*) are exposed to mixtures of a variety of chlorinated benzenes and phenols which are known to exert toxicity via different modes of action. Using a newly developed cryoextraction method, the concentration of each toxicant in the fish is determined directly for uptake/depuration studies and acute lethality bioassays. The measured values can be compared to theoretical ones based on established critical body-residues and an additive model of toxicity. The use of a whole-body-residue based first-order kinetic model allows one to more accurately view the problem as a dynamic time dependent phenomenon where the concentration of each toxicant in the fish can be evaluated independently over a continuous time interval and related to each toxicant's critical lethal body-burden. In addition, the model breaks the mixture toxicity problem down into its toxicokinetic and toxicodynamic elements which potentially offers a more direct means extrapolating between lab and field situations.

BP39 DEVELOPMENT OF DNA PROBE(S) FOR THE DETECTION OF BIFIDOBACTERIUM SPECIES IN WATER: PHASE II

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Extensive efforts have been made in recent years by the Ontario Ministry of Environment to identify and eliminate sources of fecal pollution in waters. However, identification of the original sources of pollution has been difficult. Recent field studies conducted in Ontario have suggested that densities of *Bifidobacterium* spp. could be used to trace the sources of human fecal wastes. The general scope of this study was to develop DNA probes for the detection of *Bifidobacterium* spp. in water. In order to obtain a DNA probe that is specific to *Bifidobacterium* spp., 130 recombinant clones picked randomly from a genomic library of *B. adolescentis* ATCC 15703 were hybridized to chromosomal DNA of B. longum. Clones that showed strong hybridization signals should contain DNA inserts that are conserved in both B. adolescentis and *B. longum* and were characterized further. Recombinant clones pA34 and pA63 exhibit some specificity to Bifidobacterium as these two clones hybridized to DNA of three Bifidobacterium species tested. Subsequent hybridization analyses revealed that radioactively-labelled pA34 probe hybridized strongly to DNA of *B. adolescentis, B. longum, B. breve* (two different strains) and *B. bifidum* but weakly to DNA of *Escherichia coli* and *Shigella sonnei* and not to DNA of *Lactobacillus caseii, Campylobacter jejuni*, and *Pseudomonas aeruginosa*. The radioactive pA34 probe could detect as low as 10 ng DNA and a minimum of 2 X 105 cells of B. Adolescentis. The insert in pA34 was sequenced and found to share 64% homology to part of the DNA sequence of ribosomal protein L5 of *E. coli*. The sequence information available would enable a design of more specific probes toward *Bifidobacterium* spp. that could be used in determining the sources of microbial water contamination.

AP40 BASIC AND APPLIED STUDIES WITH A TRACE ATMOSPHERIC GAS ANALYZER.

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Our objectives have been to establish a collaborative research facility, using the SCIEX TAGA 3000, at Trent University and to study to gas-phase chemical reactions which occur in the AOI source and which may improve the sensitivity of the instrument to a variety of compounds. This work was carried out in association with the Ontario Ministry of the Environment, Air Resources Branch.

The SCIEX TAGA series of mass spectrometers utilize

an atmospheric pressure ionization (API) source. The ionization of trace analytes is accomplished by the transfer of protons from the ionizing species (generally water clusters) to the target analyte. A new source arrangement has been designed based on the results of our initial experiments.

Our recent experiments have included an examination of the gas-phase reaction of ethanal and hydrazine molecules to form the ethanal hydrazone product: preliminary results indicate that the hydrazone product gives rise to a protonated ion signal intensity that is some 70 times more intense than the ethanal signal alone (ie. unreacted with hydrazine). The reaction of hydrazine with methanal is also being studied

BP40 NOVEL BIOASSAYS FOR SOILS.

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The techniques available to assess contaminated soils are not well developed and lag considerably the developments for contaminated aquatic environments. Bioassays are an important part of assessment, especially when the contaminants are unknown or mixed. We undertook to improve some the established bioassay protocols and to develop some new ideas. The short-life-cycle *Brassica rapa* selections, called "Wisconsin Fast Plants", allow relatively quick bioassays based on plant reproductive response. Modifications of earthworm bioassays using commercial bait worms and multiple replicates of single-animal units reduces costs and variability. A novel microcosm technique, based on counts of microarthropods, shows promise because of simplicity and good sensitivity. The methods have been tested with zinc, mercury and uranium, and compared with seed germination tests in soil and aquatic-species tests on soil-water extracts.

AP41 DEVELOPMENT OF A HEPATIC MICRONUCLEUS ASSAY IN FISH

C.D. Metcalfe and C.R. Williams; Environmental and Resource Studies Program, Trent University, Peterborough, Ontario K9J 7B8.

An *in vivo* hepatic micronucleus assay with rainbow trout was developed to test for the genotoxic effects of aquatic contaminants. An assay protocol was developed in which proliferation of hepatocytes in the trout liver is stimulated by a regenerative response after exposure to allyl formate (AF). The indirect-acting clastogen, diethylnitrosamine (DEN), and the direct-acting clastogens, ethyl methanesulphonate and mitomycin C, all gave a positive response in this assay. The assay was tested for potential as a biomarker of genotoxicity in fish by sampling English sole from Puget Sound, Washington. Sole from the contaminated Duwamish Estuary had an elevated micronucleus frequency of 5 micronuclei per 1000 hepatocytes in comparison to a mean micronucleus frequency of 0.5 micronuclei per 1000 hepatocytes in sole from the relatively pristine Useless Harbour.

BP41 STANDARDIZED REARING MATERIALS AND PROCEDURES FOR *HEXAGENIA*, A BENTHIC AQUATIC BIOASSAY ORGANISM: SERIAL DILUTION BIOASSAY FOR SEDIMENT TOXICITY TESTING AND ORGANISM CALIBRATION.

J.J.H. Ciborowski*, E.C. Hanes and L.D. Corkum, Department of Biological Sciences. University of Windsor, Windsor, Ontario.

Studies of sediment toxicity are often not comparable because stan-dardized reference sediments and test animals are unavailable. We used a synthetic reference sediment (42:42:16 w/w silica sand:scul-ptor's clay:potting soil) to dilute highly contaminated Detroit R., MI sediment. Laboratory-reared larvae were subjected to either 21-d or to lifetime (244-d) exposures of a sediment dilution series (1:0, 1:1, 1:3, 1:7, 1:15 or 0:1 contaminated:reference). Over 244 d, com-plete mortality occurred in the 1:0 mixture. Adults emerged only from dilutions >1:3. However, effects of contaminated sediment on 21-d survival and growth of large Hexagenia were not significant. Thus, contaminant- induced mortality was not an acute response. Gas chromatographic analysis of organochlorine contaminants in sedi-ments, larvae and emerging adults indicated significant compound-specific variability in dilution ratios and patterns of uptake. Contaminant uptake patterns by larvae among dilutions in short-term exposures were markedly nonlinear: strongly hydrophobic compounds were underrepresented in larvae reared in the most contaminated dilution. Lifetime-exposure larval: sediment and adult:sediment contaminant ratios were compound-specific but con-stant among dilutions. These important data can be used to directly infer sediment contamination levels from field-collected organisms. Parallel serial dilution sediment tests conducted on other benthic indicator organisms could considerably enhance the value of indicator organisms in reflecting sediment conditions.

AP42 CHIRONOMID LARVAE AS POTENTIAL MONITORS OF SEDIMENT GENOTOXICITY.

J.J.H. Ciborowski, L.A. Hudson and J. Whyte; Department of Biological Sciences, University of Windsor, Windsor, Ontario.

Chironomids are acknowledged as potentially important indicators of the effects of sediment-bound contaminants. Sediment bioassays can indicate toxic effects on survival and growth. High incidence of antennal or

mouthpart deformities in natural populations suggest sedi-ment teratogenicity. Our laboratory is adapting two chromosomal visualization techniques for use with chironomids to provide a direct assay for sediment genotoxicity. Chironomids, like many other Diptera, possess giant polytene chromosomes in their salivary glands. Banding patterns can be used to characterize genetically unique but morpho-logically indistinguishable populations. Exposure of larvae to toxic contaminants may be reflected as chromosomal breaks, or in changes in the frequency of puffs (swellings) at possibly characteristic loca-tions on specific polytene chromosomes. We are also attempting to differentially stain chromosomes in mitotically active diploid tissue (wing bud and neural) to assess frequencies of sister chromatid ex-changes (SCEs). SCEs are more common in tissues exposed to mutagenic agents. Successful application of these techniques to chironomids could yield an animal that may be used to simultaneously indicate toxic stress (puffing frequencies), teratogenicity (incidence of deformities) and mutagenicity (SCE frequency) of sediments.

BP42 THE USE OF ENVIRONMENTAL ISOTOPE SURVEYS IN ASSESSING CONTAMINATION POTENTIAL FOR 'CONFINED' AQUIFERS.

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The overall objective of this investigation has been to determine whether a linear morphological feature (LMF) is responsible for localized rapid recharge of the water supply aquifer in Essex County, Ontario. Previous research (Desaulniers *et al.*, 1981) reported that the aquifer is well-confined by >25 m of low permeability clayey overburden. Based on a regional survey of ^{18}O and ^{3}H concentrations in the aquifer, Crnokrak (1991) concluded that the central part of the aquifer contains anomalously young groundwater. The location of the young groundwater was problematic since rapid recharge through the confining layer was unlikely and since the young groundwater seemed remote from the likely groundwater recharge area. This enclave of young groundwater coincides with the location of an LMF that Morris (1989) suggests is an esker buried beneath the clayey overburden. In the first year of this study, Sklash and Ainslie (1991) confirmed the presence of young groundwater in the aquifer along this LMF. Their data support the buried esker concept. The specific objectives of the second year of the study were to confirm that the LMF is an esker and that recharge rates through the clayey overburden above the feature are rapid. We drilled six vertical and three angled boreholes across the LMF to further define the feature and to assess fracturing of the overburden over the feature. We analyzed porewater squeezed from the clayey overburden for ^{18}O, ^{2}H, ^{3}H, and selected major ions. The data confirm both that the feature is an esker and that recharge through the >25 m of clayey overburden occurs in less than 40 years. This investigation demonstrates that combined regional environmental isotope surveys of 'confined' aquifers and site specific depth profiling of environmental isotopes through the 'confining' unit improves the landfill site selection process.

AP43 CARCINOGENICITY TESTING OF BLEACHED KRAFT MILL EFFLUENT USING *IN VIVO* AND *IN VITRO* ASSAYS

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In vivo and *in vitro* assays were used to determine whether bleached kraft mill effluents (BKME) have the potential to be carcinogenic to fish. BKME extracts were prepared by column chromatography with XAD resins. Non-polar to medium polarity compounds were extracted using XAD-4 resin, and polar compounds were extracted using XAD-7 resin. Mutagenic activity was detected in XAD-7 extracts using the Salmonella fluctuation assay. When extracts were i.p. injected into rainbow trout, histopathological analysis showed that both XAD extracts were hepatotoxic. Changes to the ultrastructure of trout hepatocytes after exposure to low concentrations of XAD-4 extract indicated that hepatotoxicity may be mediated through peroxidative injury. BKME extracts were tested for carcinogenicity using an in vivo assay with rainbow trout. Repeated exposures to XAD-4 extracts induced lesions indicative of chronic liver injury, but no neoplastic or preneoplastic lesions were seen. When trout were exposed to sub-carcinogenic doses of aflatoxin B1, a potent hepatocarcinogen, subsequent dosing with XAD-4 extract induced subtle pre-neoplastic lesions.

BP43 DEVELOPMENT OF A GEOGRAPHIC INFORMATION SYSTEM APPLICATION FOR WATER QUALITY MANAGEMENT AND POLICY DEVELOPMENT.

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Non-point sources are a significant and continuous source of toxic and conventional pollutants to surface waters. Over the last decade, significant improvements in water quality have been realized through efforts of the Ministry of the Environment to control many point sources of nutrients and organic matter by implementation and enhancement of treatment facilities. It is becoming increasingly clear that control of non-point sources is necessary in order to achieve additional improvements in water quality.

Geographical Information Systems (GIS) offer water

resource managers a very powerful management tool for assessing non-point sources of pollution in surface waters. GIS can integrate hydrological, topographical, soil and land use data into an efficient database management environment, which facilitates both critical source area assessment, and on-going management of land use practices.

The main objective of the research is the development of a GIS Application for undertaking critical source area assessment of agricultural non-point pollution sources. The GIS Application incorporates the following modules for non-point source water quality assessment and management:

1) Erosion model based on Universal Soil Loss Equation. 2) Sediment yield water quality model. 3) Water quality management model for critical source area assessment.

The GIS Application builds on the topological relationships developed in a Vector-based GIS database. The Application modules are written in SQL and make full use of relational database management operations.

The water quality model has been developed such that the effect of the change of land use, at the property level, on in-stream water quality can be assessed.

The Application consists of the following five main components:

1) Database design of base information. 2) Reference of base information to land division. 3) Reference of land division to sub-watershed areas. 4) Linkage of sub-watershed areas to watercourses. 5) Routing of watercourse information using Strahler stream order information.

The model concepts developed represent a significant step in the development of an operational watershed management model for water resources. Additional research is required to enhance our present understanding of factors influencing sediment yield.

AP44 ARE LAKE ONTARIO TROUT MORE CONTAMINATED THAN LAKE TROUT FROM INLAND ONTARIO LAKES?

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The mean polychlorinated biphenyl (PCB) content of Lake Ontario lake trout is 3000 ng/g (wet weight basis), and this has remained fairly constent through the 1980's. It is not yet certain how much of the current PCB levels in the lake trout are due to local or point-source loading versus atmospheric deposition. One approach to help resolve this question is to compare the Lake Ontario lake trout contaminant levels to lake trout from inland Ontario lakes which do not receive any point-source contaminant loading. The data used for these comparisons are from the Ministry of the Environment Sport Fish Contaminants Monitoring Program.

BP44 AA-QC: A QUALITY CONTROL EXPERT SYSTEM AND ITS INTERACTION WITH AACONTROL AND AADIAGNOSIS

Sharbari Lahiri and Martin J. Stillman; Department of Chemistry, University of Western Ontario, London, Ontario, N6A 5B7.

This paper describes the design of the quality control module AA-QC and its interaction with AAcontrol and AAdiagnosis; both of which are modules of AAexpert. AAcontrol is a real time expert system that performs automated analysis of metals by atomic absorption spectrometry. AAdiagnosis is the diagnostic module that is concerned with diagnosing problems associated with metal analyses. In AAcontrol, aspiration of each solution produces a photomultiplier tube response vs. time trace which is characteristic of the solution and reflects the status of the instrument. Comparison between the current trace and an archival copy in AA-QC leads the user to conclude the quality of the current analysis and therefore provides unique information about the quality of the data measured. The rules in AA-QC guide the sequencer in AAcontrol. Samples that give poor analytical data are analyzed a second time. If there is no improvement in the quality of data after a second analysis, AAdiagnosis is used. The knowledge in AAdiagnosis is represented in the form of a matrix in which every cause gives rise to a unique set of symptoms.

BP44A KNOWLEDGE DEVELOPMENT AND SYSTEM DESIGN FOR SIRS: AN EXPERT SYSTEM FOR USE IN RESPONSE TO EMERGENCY CHEMICAL SPILLS.

Qiwei Zhu and Martin J. Stillman; Department of Chemistry, University of Western Ontario, London, Ontario, N6A 5B7

This paper describes the knowledge development and system design of an expert system for use in response to emergency chemical spills. The object of this research is to maintain a safe community and a clean environment following accidental releases of potentially hazardous materials. Decision-making for environmental problems, such as emergency response to chemical spills, demands extensive expertise in a number of fields. The breadth of knowledge required is frequently beyond that of a single expert, and a team approach is needed to design appropriate countermeasures. In addition, because of the unpredictable nature of spills as to the time and location, experienced personnel may not always available. Such problems are ideal for solution by expert systems because expert systems provide accuracy, consistency, timeliness, and availability in their problem solving abilities. The main obstacle to the development of an expert system is the difficulty of extracting knowledge from human experts and representing this knowledge in a format that the computer can

use. In this paper, we describe a method of encoding domain expertise into a rule-based knowledge structure. SIRS (Spill Immediate Response System) is designed as a multi-tasking expert system that can use the structured knowledge base of facts and rules to give advice and suggestions on how to response to a specific chemical spill.

BP44B DIAGNOSTIC EXPERT SYSTEMS: AN ICON-BASED EXPERT SYSTEM FOR DIAGNOSIS OF PROBLEM GC DATA

Hai Du, Sharbari Lahiri, Guosheng Huang, and Martin J. Stillman; Department of Chemistry, University of Western Ontario, London, Ontario, N6A 5B7.

This paper describes the design and implementation of an icon-based expert system for diagnosing problems in routine analysis by gas chromatography. The knowledge used in this expert system contains facts and heuristics that are assembled in the form of a knowledge domain matrix. The inference engine can apply forward, backward or mixed chaining strategies to obtain a cause for the symptom observed. The knowledge base in the program includes 15 chromatogram-related symptoms and 29 causes. The system is written within Window 3.x and uses a series of windows, each representing a specific task. Any number of applications may be in progress at the same time, some of which may be suspended while a more urgent task is run. The user can enter observations easily using the icon-based interface. The expert system analyzes for instrument and operational faults based on user-supplied chromatographic symptoms. Once the most probable causes have been diagnosed, the system displays them in a ranked order

BP44C DESIGN, CODING AND IMPLEMENTATION OF EXPERT SYSTEMS IN ENVIRONMENTAL ANALYTICAL CHEMISTRY.

Martin J. Stillman, Sharbari Lahiri and Guosheng Huang; Department of Chemistry, University of Western Ontario, London, Ontario, N6A 5B7.

Over the last 5 years we have studied techniques to be used in the design of expert systems for use in the environmental analytical laboratory. We have identified a number of different classes of expert system that can operate as advisors to the analyst: (i) diagnostic experts, for both instrumental and chemical problems, (ii) method selection experts, which involve a combination of rules and database access, (iii) real-time experts, which use rules to control instrumental operation, and (iv) data analysis experts, which aid the analyst in the interpretation of spectral data. In this paper we will describe significant progress in the development of components that are central to the success of the design and implementation of these expert systems. We have developed (i) a new graphically based user interface, (ii) new and advanced methods to encode knowledge, and (iii) a new inference engine. Significant progress has been made in the knowledge encoding step. Novel techniques have been developed so that the knowledge base can verified and audited by other experts, because the knowledge base is readable, and because the knowledge base is portable, an industry-wide knowledge base can be developed that could hold rules and facts associated with, for example, regulations concerning maximum contaminant levels and approved analytical methods.

AP45 AUTOMATABLE TOTAL CYANIDE ANALYSIS.

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This project is concerned with the development of an automatable analysis system for the measurement of total cyanide concentration. The technique of determining total cyanide concentration in synthetic waste water using UV photodissociation of the cyanide complexes and ion chromatography (IC) with electrochemical (EC) and UV spectro-photometric detection has been found to be satisfactory. Ferrocyanide and ferricyanide complexes have been completely UV photodissociated in about 8-10 minutes of irradiation with 100% of the free cyanide measured with the IC using EC detection, in solutions containing a reducing agent (0.5% of hypophosphorous acid) at a pH 13. The thiocyanate species, a potential interferent, does not photodecompose to cyanide under UV irradiation when the shorter wavelengths have been excluded. Cut-off filters above 305 nm have been shown to be effective. A mixture of ferrocyanide and ferricyanide complexes with and without thiocyanate present, also resulted in a 100% detection. An increase in the intensity of the UV irradiation was found to achieve the same degree of photodecomposition in a shorter time. The automatable system would measure a total cyanide concentration as free cyanide in about 10-12 minutes after the injection of the sample.

BP45 SURROGATE ANALYSIS OF TRACE LEVELS OF VOLATILE POLAR ORGANIC COMPOUNDS IN DRINKING WATER

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The analysis of trace levels of polar compounds, particularly those which are very soluble in water, presents a significant challenge in the determination of water quality. There are two main sources of these compounds in drinking water, pollution and the disinfection of water by chlorination. The purpose of this project

is to determine the feasibility of a surrogate analyzer to detect volatile polar organic compounds. Surrogate analysis allows the required specificity of the analysis to be reduced to include a class of compounds rather than specific members of the class. This may be accomplished by a portable, easy to use instrument. If a positive response is obtained, the water samples may then be forwarded for much more expensive specific analysis by gas chromatography and mass spectrography.

The analytical process may be broken into two steps, detection and separation. The detector must be capable of responding to trace levels of the compounds of interest and a specific response is desirable. Two detectors systems will be discussed in the context of this project. These are the Electron Capture Detector (ECD) and the Piezoelectric Sorption Detector based on coated quartz crystals. The ECD is one of the most sensitive detectors and it is also selective, responding to electronegative compounds or atoms. By separating the polar compounds from the water by a polar liquid membrane, interferences may be reduced and the concentration of the polar compounds increased. Two main interferences, oxygen and water have been found to present the greatest difficulties. While not as sensitive as the ECD, the quartz crystal sensor can be made selective in its response to polar compounds. Its main advantages are that it may be used without a carrier gas and it is quite inexpensive. By coating an array of crystals with liquids of different polarity, the selectivity of the crystal sensor system may be increased.

AP46 THERMAL DESORPTION OF SOLID PHASE EXTRACTION COLUMNS FOR THE LOW LEVEL MEASUREMENT OF ORGANIC COMPOUNDS IN WATER.

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The feasibility of performing Solid Phase Extraction (SPE) of organic compounds, from water samples, in conjunction with thermal desorption to a gas chromatograph has been evaluated. Using wall coated open tubular (WCOT) columns, for solid phase extraction, and dual capillary WCOT analytical columns, a system was developed for the quantitative recovery of polychlorinated biphenyls from water with detection limits of 1 ng/L using electron capture detection.

The study involved the development of a system allowing the examination of variables affecting SPE and thermal desorption to a gas chromatograph. The system included a 6 port valve, a pressurized vessel for transferring the water sample to the SPE column and cryofocussing to improve chromatographic performance and sensitivity. The SPE column, in this system, was thermally desorbed without the need for a separate heating chamber because the SPE column was positioned in the gas chromatograph oven; temperature programming of the GC oven effected desorption from the SPE column.

The system developed is rugged and, by adapting hardware currently available on the market, could potentially function in an automated fashion for drinking water. The savings in labour relative to the methods in current use at the Ministry are significant. In addition, since all the extracted analytes are determined by gas chromatography, only a small amount of sample (10 millilitres compared to 1 litre) is required to perform a determination with ultra low detection limits.

BP46 MICROWAVE BASED HORIZON TECHNIQUES FOR RAPID SAMPLE DIGESTION.

J. Guy Légère, Huinan Yu, Anne Morinville and Eric D. Salin; Department of Chemistry, McGill University, Montreal, P.Q., H3A 2K6.

While microwaves seem to offer considerable advantage for rapid digestions, the handling processes can be quite laborious. This is particularly true with bombs, which offer the advantages of higher temperatures and pressures and a consequent very rapid digestion capability. We have developed tube based systems which combine the advantages of flowing techniques with the speed of bomb microwave digestions. We will discuss the characteristics and performance of two systems, one designed exclusively for liquids and another designed for solids.

AP47 CONSIDERATIONS FOR ULTRA TRACE LEVEL DETERMINATIONS IN FLOW INJECTION-DIRECT SAMPLE INSERTION ICP SPECTROMETRY

Robin Rattray, Jorge Minoso and Eric D. Salin; Department of Chemistry, McGill University, Montreal, P.Q.

Recent work with the Ministry of the Environment has revealed some difficulties that can arise when using sensitive techniques like inductively coupled plasma mass spectrometry with preconcentration techniques such as ion exchange or adsorption separation. We will discuss our experience using flow injection - mass spectrometry as well as discussing another technique which may overcome some of the problems of preconcentration for ultra trace spectrometry.

BP47 THE MEASUREMENT OF ATMOSPHERIC GASES BY THERMAL EMISSION SPECTROSCOPY

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The measurement of atmospheric gases by thermal emission spectroscopy with FTIR technology is described. In particular, CFC11, CFC12, $HN0_3$, NO_2, SO_2, C_2H_4, CH_4, C_4H_{10} and N_2O_5 have been observed. These are of importance for investigations of the tropospheric chemistry of air pollution and global warming. Models of the global warming use laboratory absorption spectra of gases as a basis for radiative transfer calculations. In the atmosphere, the greenhouse effect actually arises through the emission of Planck blackbody radiation from atmospheric gases and aerosols. A technique has recently been developed for measuring the thermal emission spectra of gases in a infrared cell in the laboratory. The gases measured include CFC11, CFC12, CFC11, ethylene and nitric acid. Atmospheric spectra indicating the presence of the same gases have been measured. It is shown that absorption spectra of these gases may not be adequate for detailed radiative transfer calculations in greenhouse models.

AP48 ANALYSIS OF ORGANIC COMPOUNDS BY LIQUID CHROMATOGRAPHY/MASS SPECTROMETRY (LC/MS).

C.J. Koester and R.E. March; Department of Chemistry, Trent University, Peterborough, Ontario, K9J 7B8, and D. T. Wang and V. Y. Taguchi, Laboratory Services Branch, Ontario Ministry of the Environment, Rexdale, Ontario, M9W 5L1.

The analysis of organic compounds in environmental matrices requires techniques which separate and identify the individual components in a mixture. Gas chromatography/mass spectrometry (GC/MS) is commonly used for this purpose; however, compounds that are thermally labile, highly polar (non-derivatized), or non-volatile are not amenable to analysis by GC/MS. Liquid chromatography coupled with mass spectrometry is becoming an important complementary technique for the detection of compounds that cannot be analyzed by GC/MS. The goal of this work is to set up and optimize a LC/MS system for the identification of known (target compounds) and unknown compounds in extracts taken from various environmental matrices. The LC/MS system consists of a ternary gradient Hewlett Packard 1090 LC equipped with a reversed phase column (2.1 mm x 25 cm, C18), and a diode array detector coupled in series with a particle beam interface (VG LINC) to a single quadrupole mass spectrometer (VG Trio-2). This system allows the acquisition of library-searchable electron impact (EI) spectra as well as chemical ionization (CI) spectra. The target compounds presently being investigated are carbaryl, carbofuran, diuron, linuron, siduron, and rotenone. LC/MS was also used to characterize the waste water components N, N'-diphenyl urea and N, N'-ethanediamine, which were not detected by GC/MS. LC/MS will enhance the characterization capabilities of the mass spectrometry laboratory and will allow the confirmation of the presense of compounds detected, but not unambiguously identified, by conventional LC detectors.

BP48 STABILITY OF POLYNUCLEAR AROMATIC HYDROCARBONS IN CHLORINATED DRINKING WATER SAMPLES.

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Polynuclear aromatic hydrocarbons (PAH) are ubiquitous environmental pollutants. The carcinogenic nature of some PAHs has elicited their inclusion in environmental control guidelines and legislation. The Ontario Ministry of the Environment has established the maximum acceptable drinking water guideline (MAC) for benzo(a)pyrene as 10ng/L. When dealing with guidelines involving trace level analytical techniques and results, it is particularly important that sample integrity is maintained. In other words, final analytical results should truly represent the analyte concentrations in the original sample.

PAH data generated from finished (chlorinated) drinking water samples indicates some PAHs of interest decrease in concentration during storage. Laboratory studies to determine the effect of water chlorination on the stability of thirteen polynuclear aromatic hydrocarbons in stored drinking water samples were undertaken. Studies were conducted over a two month period. The use of sodium thiosulphate and sodium sulphite for sample preservation were simultaneously evaluated. Water chlorination caused the levels of several PAHs to decrease by as much as 100% in stored samples over the duration of the study. Sodium thiosulphate effectively retarded PAH losses while sodium sulphite had little effect.

AP49 APPLICATION OF A MULTI-DIMENSIONAL CHROMATOGRAPHIC / MASS SPECTROMETRIC DETECTION SYSTEM TO TRACE LEVEL PESTICIDES ANALYSES.

P.W. Crozier and C.D. Hall; Ministry of the Environment, Rexdale, Ontario, M9W 5L1.

Analysts are continually asked to lower method detection limits while maintaining the integrity of the analytical results generated. Lowering method detection limits can be accomplished through wet chemical

preparation manipulations or instrument modifications. Multidimensional chromatography is an instrument technique which has been used successfully for analyte enrichment as well as characterization of complex samples. Although trace level analyses and characterization are possible through the use of high resolution mass spectrometry systems, there are many inherent problems. Multidimensional chromatography coupled to low resolution mass spectrometry instrumentation has the potential to allow semi-automated trace level analysis and characterization of samples without the expense and problems associated with high resolution mass spectrometry.

A multidimensional chromatography system, based on Deans switch technology, was installed in a gas chromatograph coupled to a mass selective detector. The system consists of a 20m x 0.53mm ID fused silica pre-column linked to a 30m x 0.25mm ID fused silica analytical-column by means of two valves and a short section of deactivated fused silica tubing covered by a metal sheath (CO_2 cryogenic-trap). The pre-column accepts large volume solvent injections and roughly separates the solvent and analytes while the analytical-column is used for the actual analytical separations and analyses. The valves and CO_2 cryogenic-trap are the pivotal hardware of the system, allowing the versatility to heart-cut and cryo-focus any portion of the rough chromatogram for more detailed evaluation.
Good quantification (4.7% relative standard deviation at low pg/uL levels) and retention time (0.14% relative standard deviation) reproducibility were obtained with the system. Full scan instrument detection limits (IDLs) of < 10pg/uL were obtained for alachlor and metolachlor with excellent library matches. Selected ion monitoring IDLs of < 0.5pg/uL were obtained for some tetrachlorobenzenes and trichlorotoluenes (parent ion and at least one qualifying ion).

BP49 ANALYSIS OF SEWAGE SLUDGE FOR 100 ORGANIC PRIORITY POLLUTANTS AT PART PER BILLION LEVELS.

R. Lega, J. Ladwig and I. Ahmad

Concern about water pollution and hazardous waste control, backed by stringent regulations such as Ontario's Municipal and Industrial Strategy for Abatement (MISA) program has increased the interest in the behaviour and fate of a wide range of organic contaminants during the wastewater treatment process. There are about 400 sewage treatment plants (STP) in Ontario, which receive domestic and industrial wastewater and urban run-off. As a result of the wastewater treatment process, a dischargeable effluent and a sewage sludge are produced.

To characterize the quality of the sewage sludge and evaluate the concentration and frequency of occurrence of organic pollutants, we have developed an effective and rapid analytical method. This method allows the analysis of 96 extractable organic target pollutants utilizing the following steps: a) extraction using solvent mixtures, sonication and centrifugation, b) separation of target compounds from interferences by gel permeation, open-column chromatography using Florisil and activated copper treatment, c) derivitization of acidic components including phenols and d) confirmation and quantitation of target compounds by GC/MSD

The existence of reliable analytical data to characterize the final sludge product will facilitate the application of the sewage sludge for its advantageous qualities in agriculture or determine the appropriate way of disposal to avoid contamination of the environment and protect public health.

AP50 CHARACTERISTIC LEVELS OF CHLORINATED DIBENZO-P-DIOXINS AND CHLORINATED DIBENZOFURANS IN ONTARIO LAKES.

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The analysis of Ontario sport fish is important for human health protection. Advice on consumption of fish from over 1,700 locations in Ontario, tested for up to 70 different chemical substances is given in the annually revised bilingual "Guide to Eating Ontario Sport Fish". Congener specific analysis for the polychlorinated dibenzo-p-dioxins (PCDDs) and chlorinated dibenzofurans (PCDFs) now forms an important component of the analytical scan for sport fish. Low detection limits are required for the analysis of PCDDs and PCDFs due to the toxicity associated with these compounds, thus very sensitive and selective instrumentation (i.e. MS/MS or HRMS) techniques are required. Fish data, in particular congener patterns (TCDD/TCDF ratios), are characteristic of the various locations in Ontario from which fish have so far been tested. The Ministry of Environment is now performing toxic congener analysis which enables identification and monitoring of sources and locations. Various different congener patterns will be discussed.

BP50 DEVELOPMENT OF A NEAR REAL TIME CONTINUOUS MERCURY ANALYSER.

A.C. Ng, G.B. DeBrou, M.D. Corbridge, D.R. Schneeberger, and F.H. Schaedlich; Air Resources Branch, Ontario Ministry of the Environment, Toronto, Canada, M5S 1Z8 and Tekran Inc. Toronto Canada. M6E 2V1.

The long term health effects of exposure to high levels of mercury has long been known. Recent work has indicated, however, that even very low levels of mercury can bio-accumulate to potentially toxic levels. Long range transport and atmospheric emissions from local industries and municipal incinerators have been suspected as major sources of mercury in water, however, measurements of low levels in air has posed consider-

able difficulties. Real time analysers suffered from lack of sensitivity. Low level measurement had required long term (6 or 24 hour) sampling onto an adsorbent cartridge, with subsequent thermal desorption. These methods suffered from losses and memory effects in the adsorbent and were affected by meteorological conditions.

To overcome these shortcomings, an instrument to detect and quantify levels of less than 1 ng/m^3 with a measurement period of ten minutes was developed. A dual cartridge design allows continuous sampling of the ambient air stream. Mercury in a known volume of ambient air is trapped on a pure gold adsorbent which is subsequently thermally desorbed in argon. The desorbed mercury is detected using cold vapour atomic fluorescence spectrophotometry (CVAFS). Calibration is achieved by direct injection of a known volume of saturated mercury vapour. A series of performance tests were run to establish linearity to beyond 40 ng/m^3. The detection limit was determined to be 0.12 ng/m3 (100 ppq). No interferences were found. The memory effects long associated with pure gold adsorbent was not observed at the cycle times and loadings used in this instrument.

The instrument is self contained and capable of continuous operation in remote locations as well as mobile operations. It was used to confirm that background readings in some areas of Toronto are from 2 to 4 ng/m3. The capabilities of this analyser make it suitable for a range of applications including studies of long range transport, urban air toxics, mercury spills and the identification of sources.

AP51 NON-SELECTIVE DETECTION OF MUTATIONS BY SINGLE STRAND CONFORMATIONAL POLYMORPHISM ANALYSIS (SSCPA).

E. Fan, D.B. Levin and D.M. Logan; Department of Biology, York University, North York, Ontario M3J 1P3.

In spite of its daunting title SSCPA has proven to be a remarkable new technique for the direct detection of mutations in DNA. Mutations in such diverse genes and tissues as the P53 gene in brain tumours, small cell lung cancers, and the insulin receptor gene have all been identified with relative ease. The technique is said to be non-selective because one measures DNA changes directly rather than selecting for a particular phenotype such as revertants in the Ames assay. It is thus a significant improvement in mutagen detection. The basic concept of the assay is straightforward. Single stranded DNA assumes a structure which affects its electrophoretic mobility. When a base substitution or deletion occurs the structure changes and such "mutant" strands are identified by altered mobility. We have been characterizing the assay using mutants of known DNA sequence from the DNA binding domain of the lacI gene from *E. coli*. DNA target sequences are amplified by PCR, denatured and run on SSCP gels where mutant sequences migrate at rates different from wild type. The process is reproducible, highly effective for sequences up to at least 400 bp in length (>90% of all mutants are detected) and apparently insensitive to the position of mutations in the target sequence. One particular problem with the assay is the fidelity of DNA amplification in the PCR reaction. Detection of infrequent mutants requires high fidelity of the PCR polymerases. Here we have adjusted conditions to improve fidelity by at least a factor of 10. Finally, the electrophoretic mobility of DNA fragments is thought to relate to their secondary and tertiary structures. We are examining the base stacking in normal and mutant strands to test whether mobility can be related to base stacking.

BP51 DETERMINATION OF RATE CONSTANTS FOR THE AQUEOUS PHOTODEGRADATION OF POLLUTANTS BY HYDRATED ELECTRONS USING A SPIN TRAP/ELECTRON PARAMAGNETIC RESONANCE METHOD

Aitken R. Hoy and James R. Bolton; Photochemistry Unit, Department of Chemistry, University of Western Ontario, London, Ontario N6A 5B7.

Recently it has been discovered that the photochemical generation of hydrated electrons is a potent method to remove certain halogenated organic pollutants (e.g., chloroform) from wastewaters. Solarchem of Richmond Hill, Ont. has announced a commercial process (RAYOX(R)) based on this concept. An in-depth understanding of the mechanism of this process requires knowledge of the rate constants of hydrated electrons with a variety of pollutants. However, these rate constants are known for only a few of the important halogenated organic pollutants.

In our work, we have developed a novel method for measuring the rate constants for the reaction of the hydrated electron with aqueous pollutants. Hydrated electrons are generated by the photolysis of the ferrocyanide ion and are detected using the spin trap/ Electron Paramagnetic Resonance technique. Relative rate constants are found from the competition between the spin trap and the pollutant and are converted to absolute values by calibration against known rate constants. Rate constants for a variety of molecules are presented and are compared with the literature values.

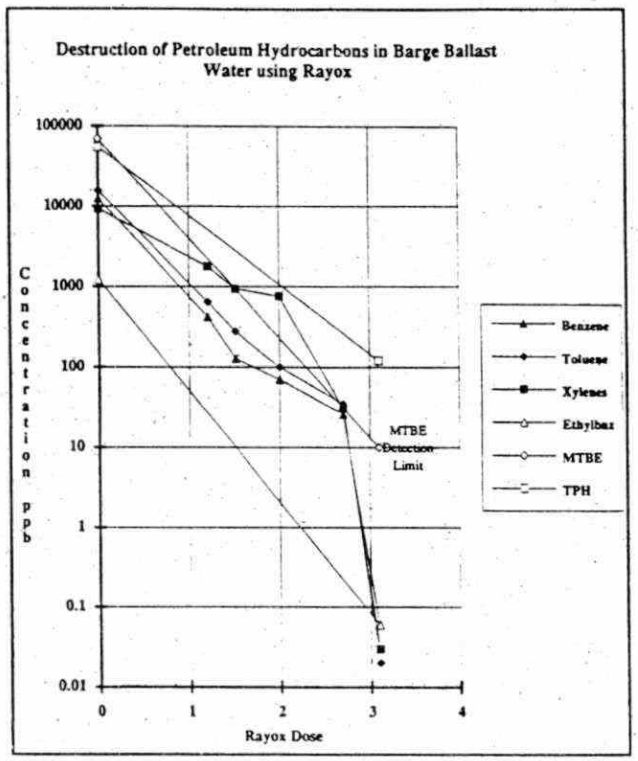
AP52 PRELIMINARY STUDIES OF THE DEVELOPMENT OF A HIGH PERFORMANCE LIQUID CHROMATOGRAPHY-PARTICLE BEAM-MASS SPECTROMETRIC METHOD FOR THE DETERMINATION OF POLYNUCLEAR AROMATIC HYDROCARBONS

Raj P. Singh, Ian D. Brindle, Xiao He, Timothy R.B. Jones, and Jack M. Miller; Chemistry Department, Brock University, St. Catharines, Ontario L2S 3A1, and Mikio Chiba; Agriculture Canada, Vineland Station, Ontario L0R 2E0.

Particle beam (PB) interface is a relatively new interface for coupling high performance liquid chromatography (HPLC) with mass spectrometry (MS). In a PB interface, HPLC effluent is pneumatically nebulized in a desolvation chamber at nearly atmospheric pressure (1). Analyte molecules in the solvent stream nucleate to form submicrometer particles in the desolvation chamber. These particles are separated from the solvent vapour molecules in a two- or three-stage momentum separator and subsequently transported to the mass spectrometer ion source. The PB interface, which enables the on-line HPLC-MS acquisition of electron-impact (EI) and/or solvent independent chemical ionization (CI) spectra, was originally developed by Willoughby and Browner (2) as a helium nebulized mono-disperse aerosol generating analyzer. At the present time, a number of PB interfaces are commercially available, normally with a concentric pneumatic nabulizer system. The sample is nebulized in the desolvation chamber by helium at flow rates 0.5 to 2.0 litre/min. To achieve higher mobile phase flow rates and to generate low pressure in the source an ultrasonic nebulizer with controlled heating of the desolvation chamber was also developed by Ligon and Dorn (3). This interface was especially developed to interface HPLC to a magnetic sector mass spectrometer. Since we are also using a magnetic sector mass spectrometer, we chose to design a nebulizing system similar to that reported by Ligon and Dorn (3). However, with this interface it was difficult to maintain a good alignment between aerosol beam, nozzle and three stage momentum separator. Poor alignment resulted in poor reproducibility and lower sensitivity. Due to these problems, we have modified our nebulizing system to the more commonly used concentric design with an ultrasonic head and three stage momentum separator. A Kratos Concept IS double-focusing mass spectrometer (Kratos Analytical, Urmston, Manchester, UK) (E/B Configuration) with EI/CI source was connected to the PB interface. A Waters 600-MS liquid chromatograph was used for HPLC separation and determination of polynuclear aromatic hydrocarbons (PAHs). The HPLC effluent is nebulized by helium flowing at 0.95 litre/min. The temperatures of desolvation chamber and source were maintained at 25-30 and 250-275 C respectively. Normally, HPLC-PB-MS has been used for the determination of polar compounds (4-7). Although it has ben suggested that HPLC-PB-MS can be used for the determination of polynuclear aromatic hydrocarbons, to our knowledge no systematic report on the determination of PAHs has been published in the literature. The purpose of this work was to develop a HPLC-PB-MS method for the determination of PAHs in environmentally important matrices. The advantage of using HPLC-PB-MS is that EI is used in the mass spectrometric source to generate mass spectra. The use of EI means that the mass spectra are searchable with conventional library searches of EI data. For most of the preliminary work on the analysis of PAHs, the analytical column was bypassed. Tests were carried out with standard solutions of acenaphthene, acenaphthalene, fluoranthrene, anthracene, phenenthrene, chrysene, dibenz[a,h]anthracene, benzo[g,h,i]perylene and coronene in order to evaluate their comparitive responses by the HPLC-PB-MS technique. Although all of these PAHs showed good responses, the sensitivity was greatest for chrysene. Dibenz[a,h]anthracene, benzo[g,h,i]perylene and coronene also showed good sensitivity.

Using 100% methanol as mobile phase at 0.5 ml/min flow rate, good signals from 0.08 picogram chrysene were obtained. Dibenz[a,h]anthracene, benzo[g,h,i]perylene and coronene can be detecteded at 0.2 to 1 ng levels. From our preliminary studies it was concluded that the sensitivity of HPLC-PB-MS method was better for relatively high molecular weight PAHs. Separation of anthracene, chrysene, dibenz[a,h]anthracene, benzo[g,h,i]perylene and coronene were achieved on a 2 mm internal diameter C-18 column. This paper will present the optimum conditions for the determination of selected PAHs by the HPLC-PB-MS method and possibilities for their determination in environmental samples.

REFERENCES (1). A.P. Tinke et al., J. Chromatogr., 554 , 119-124, (1991). (2). R.C. Willoughby and R.F. Browner, Anal Chem., 56 , 2626-2631, (1984). (3). W.V. Ligon Jr. and S.B. Dorn, Anal. Chem., 62,2573-2580, (1990) . (4). T.D. Behymer et. al., Anal. Chem., 62 , 1686-1690, (1990) . (5). D.R. Doerge and C. J. Miles, Anal. Chem., 63, 1999-2001, (1991). (6). J.S. Ho et. al., J. Am. Soc. Mass Spectrom., 3 , 662-671, (1992).



A6

Figure 1

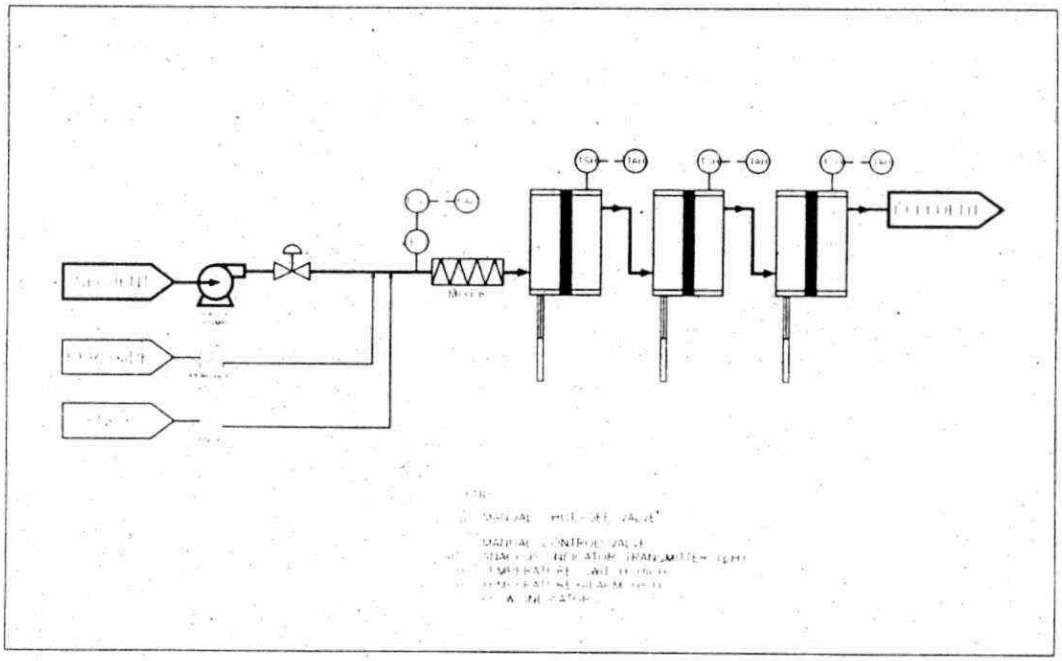


Figure 2 - Rayox Process Flow Diagram

V-1

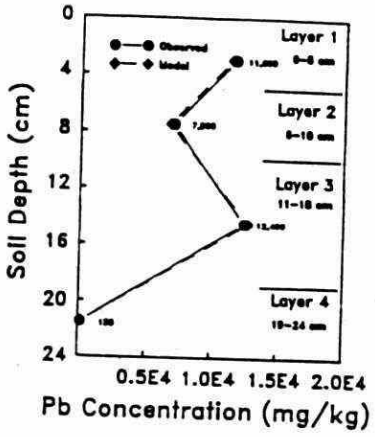


Fig. 1 Observed and predicted (model) Pb concentrations in the soil profile after 800 years.

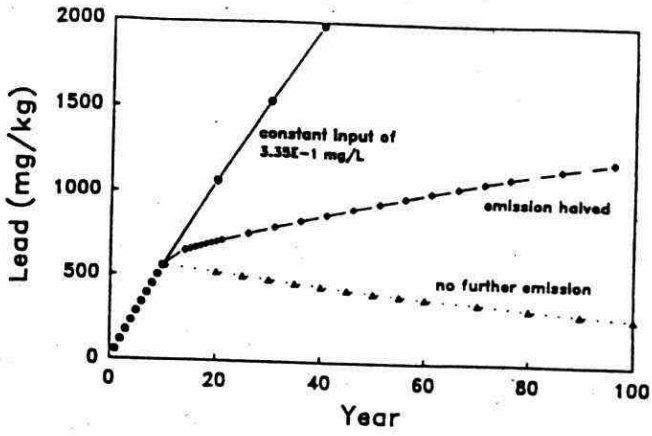


Fig. 2 Surface soil Pb concentrations with time shoving the long-term effect of continued and reduced industrial emissions.

B2

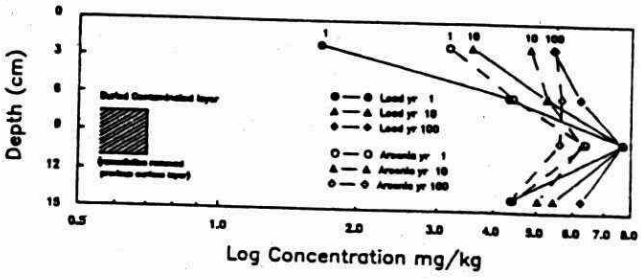


Fig. 3 Upvard migration of Pb and As in a sandy soil with time shoving the slov contamination of soil susceptible to resuspension, ingestion and inhalation from a buried source.

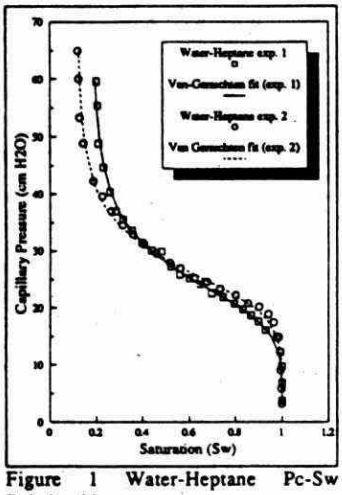


Figure 1 Water-Heptane Pc-Sw Relationship

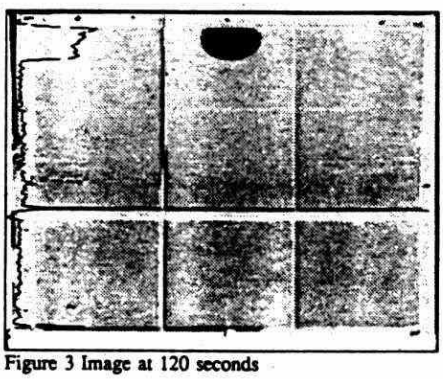


Figure 3 Image at 120 seconds

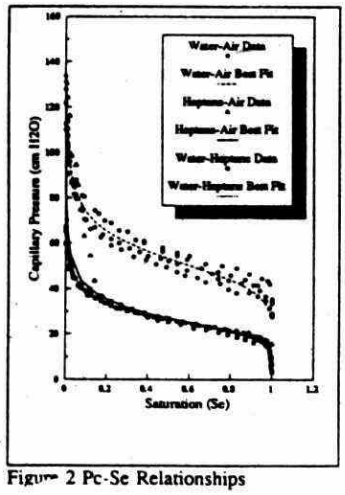


Figure 2 Pc-Se Relationships

B3

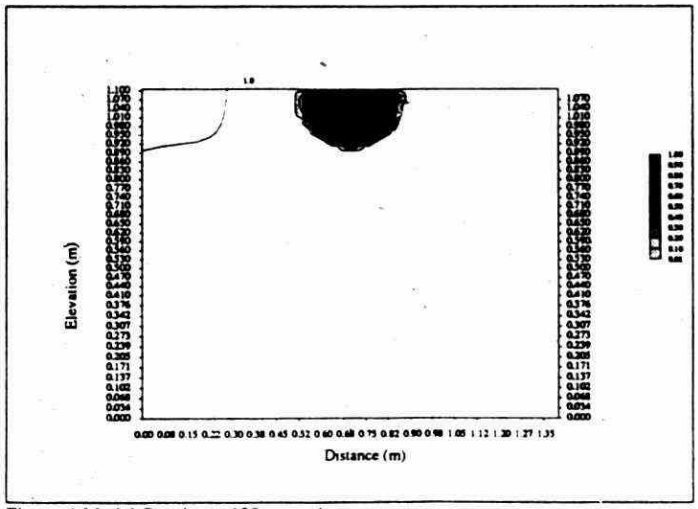


Figure 4 Model Results at 120 seconds

V-2

D1

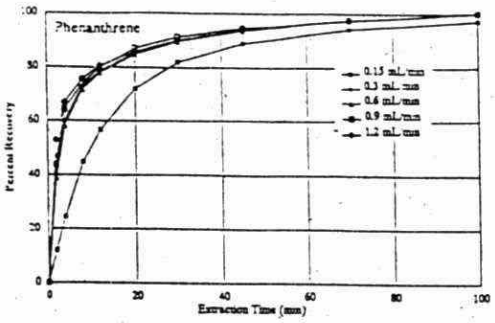


Figure 1. SFE extraction rates of phenanthrene from railroad bed soil using different flow rates of supercritical CO_2.

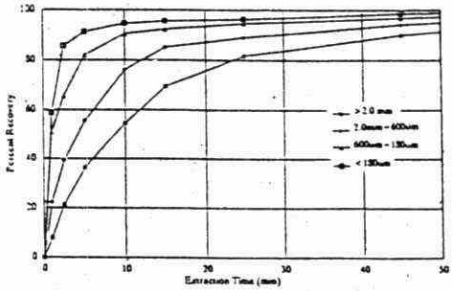


Figure 2. SFE extraction rates of triacontane from petroleum source rock using different mesh sizes of ground rock.

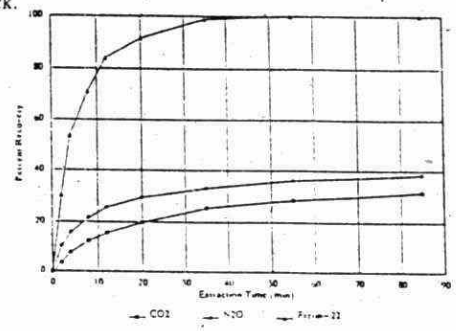
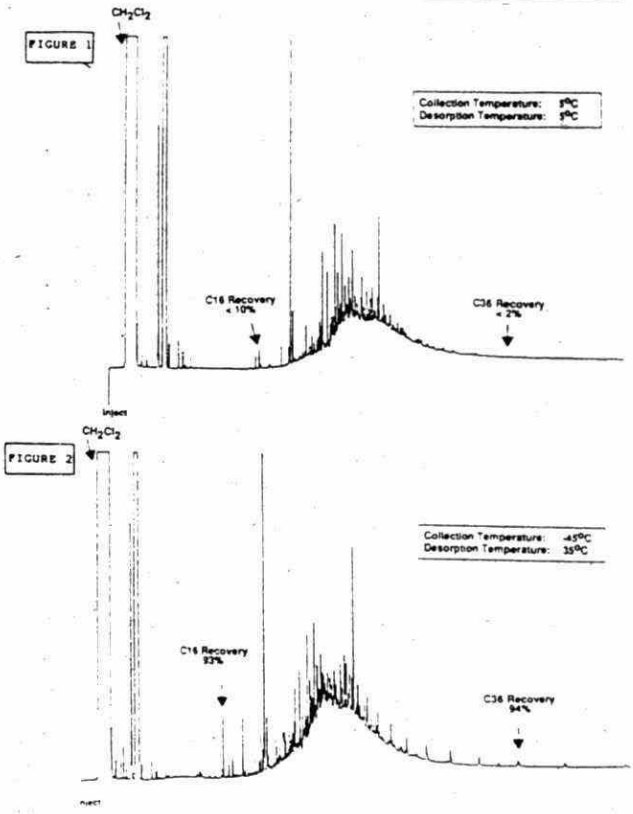


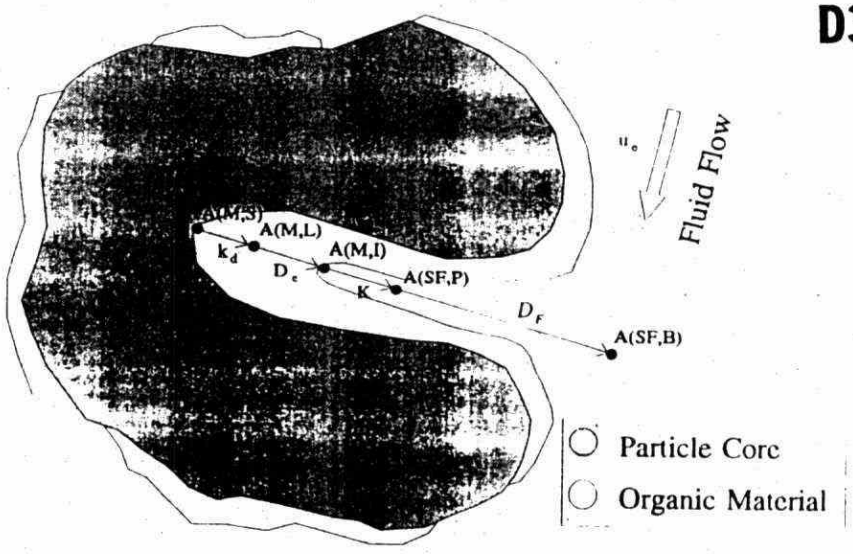
Figure 3. SFE recovery rates of chrysene from petroleum waste sludge using supercritical CO_2, N_2O, and $CHClF_2$ (freon-22).

Off-Line SFE GC Determination of Diesel Exhaust Particulate from Filters



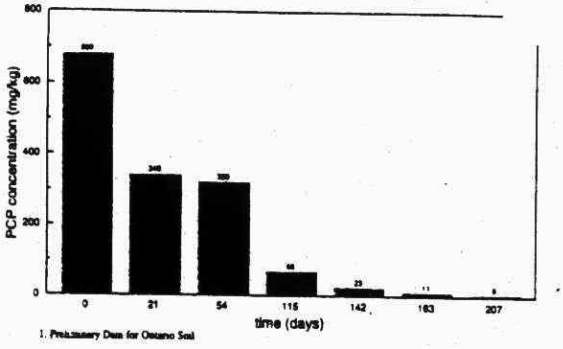
D2

D3



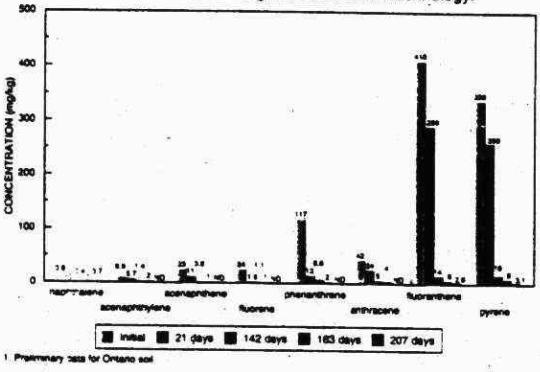
B6

Figure 1. Residual PCP concentrations in wood treatment soil treated on-site with Dearborn organic amendment technology.[1]



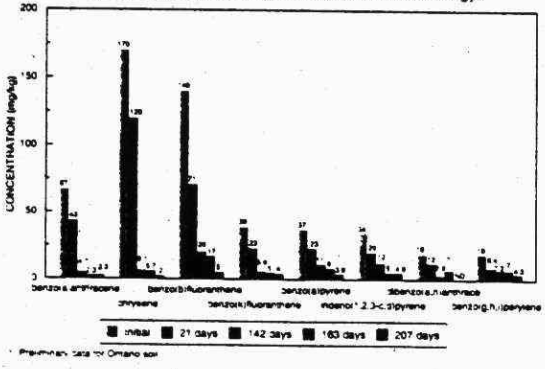
1. Preliminary Data for Ontario Soil

Figure 2a. Residual PAH concentrations in wood treatment soil treated on-site with Dearborn organic amendment technology.[1]



1. Preliminary data for Ontario soil

Figure 2b. Residual PAH concentrations in wood treatment soil treated on-site with Dearborn organic amendment technology.[1]



1. Preliminary data for Ontario soil

B9

Figure 1. National Framework for Contaminated Site Assessment and Remediation in Canada.

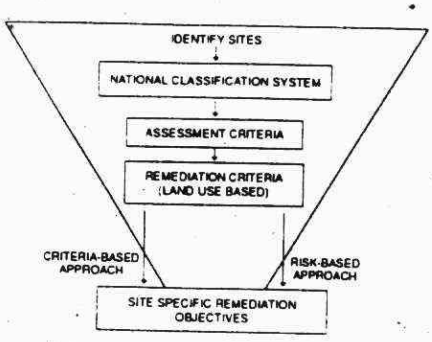
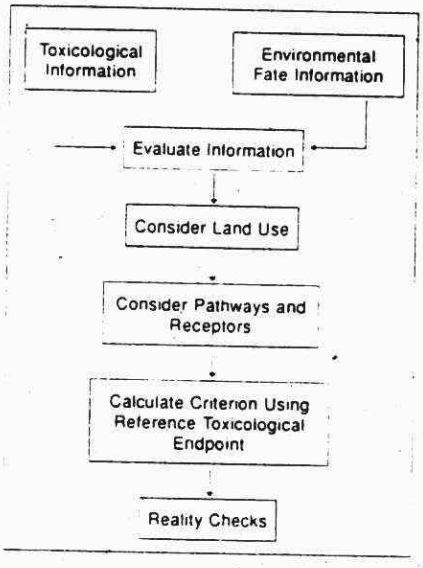


Figure 2. Information required for the Development of Soil Environmental Quality Criteria.



C8

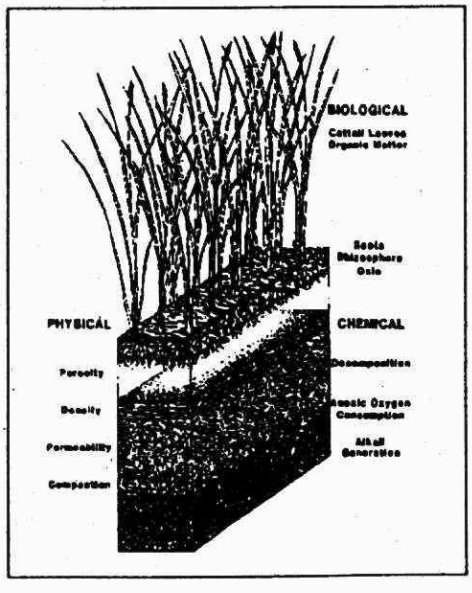


Figure 1: Schematic of the ARUM and carbon/nutrient recycling processes.

D8

PAH#1: d_{10}-acenaphthene; PAH#2: d_{10}-anthracene; PAH#3: d_{10}-pyrene; PAH#4: d_{12}-chrysene; and PAH#5: d_{12}-benzo(a)pyrene.

CH_3OH = methanol; CH_2Cl_2 = methylene chloride; $CHCl_3$ = chloroform; $C_6H_5CH_3$ = toluene; $(CH_3)_2CHOH$ = iso-propanol; CH_3COCH_3 = acetone; CH_3CN = acetonitrile; $HCON(CH_3)_2$ = N,N-dimethylformamide; $H_3COCH_2CH_2OH$ = 2-methoxyethanol; C_6H_5Cl = chlorobenzene

Table 1

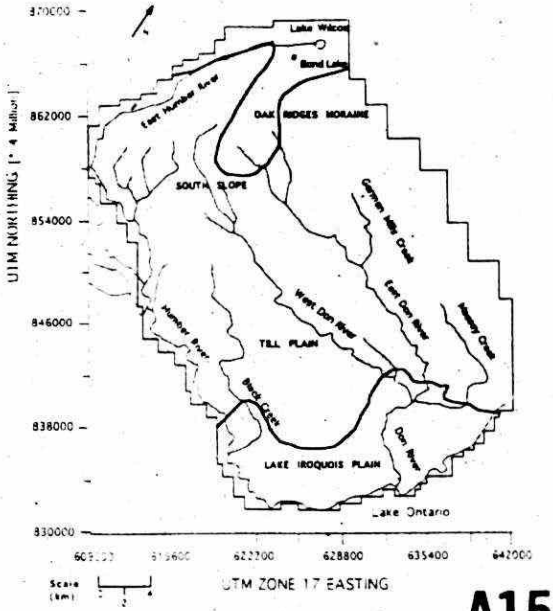
Modifier	Fluid Flow Rate (ml/min)	Used Fluid Volume (ml)	Percent Recovery PAH#1	PAH#2	PAH#3	PAH#4	PAH#5
CH_3OH [1]	≈0.25	≈13	23.7	22.0	25.1	25.4	21.2
CH_3COCH_3 [1]	≈0.25	≈13	71.1	78.0	74.6	63.3	50.1
$(CH_3)_2CHOH$ [2]	0.233	14.0	>100	57.4	47.3	43.4	35.5
$(CH_3)_2CHOH$ [2]	0.275	17.3	>100	89.7	67.4	58.5	47.6
$(CH_3)_2CHOH$ [3]	0.302	19.0	>100	>100	80.6	68.8	53.8
CH_3CN [3]	0.331	20.9	>100	>100	87.3	76.2	59.1
CH_3CN [3]	0.378	23.8	>100	>100	85.9	79.3	65.6

[1] At 420 atm and 90°C, static extraction (for 15 min) followed by dynamic extraction (for 50 min).
[2] At 430 atm and 100°C, static extraction (for 17 min) followed by dynamic extraction (for 60-63 min).
[3] At 440 atm and 100°C, static extraction (for 17 min) followed by dynamic extraction (for 63 min).

Table 2

Modifier	Fluid Flow Rate (ml/min)	Used Fluid Volume (ml)	Percent Recovery PAH#1	PAH#2	PAH#3	PAH#4	PAH#5
CH_2Cl_2	0.808	66.1	>100	98.9	79.3	75.1	59.9
$CHCl_3$*	0.582	47.1	>100	>100	85.0	76.8	58.6
$C_6H_5CH_3$	0.450	36.0	>100	>100	85.0	74.1	59.7
$(CH_3)_2CHOH$	0.593	51.0	>100	85.0	70.9	52.4	35.3
CH_3COCH_3	0.673	57.9	>100	>100	97.2	82.6	58.7
CH_3CN	0.937	80.6	>100	>100	98.4	80.1	51.4
$HCON(CH_3)_2$	0.708	60.9	>100	>100	>100	90.2	61.1
$CH_3OCH_2CH_2OH$	0.791	68.0	>100	>100	>100	90.5	68.1
C_6H_5Cl	0.789	67.9	>100	>100	>100	93.8	81.0

*Carrying 0.75% alcohol.
All extractions in Table 2 were carried out at 450 atm and 100°C statically for 15-16 min and then dynamically for 80-86 min.



A15

Figure 1 Physiography

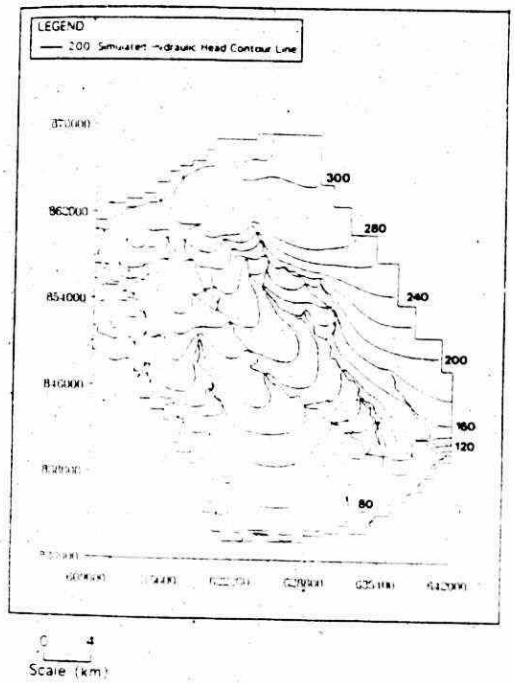


Figure 2 Simulated Hydraulic Head Distribution - Flowpath

A16

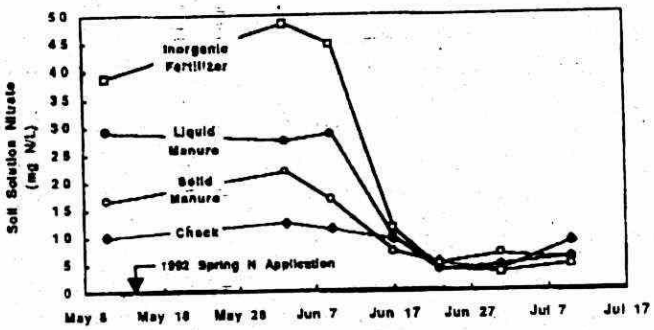


Figure 1: Effect of N-source on soil solution NO_3^--N leaving the root zone (75 cm). Data points are averaged across N-rates and times of application and thus are the means of 24 determinations.

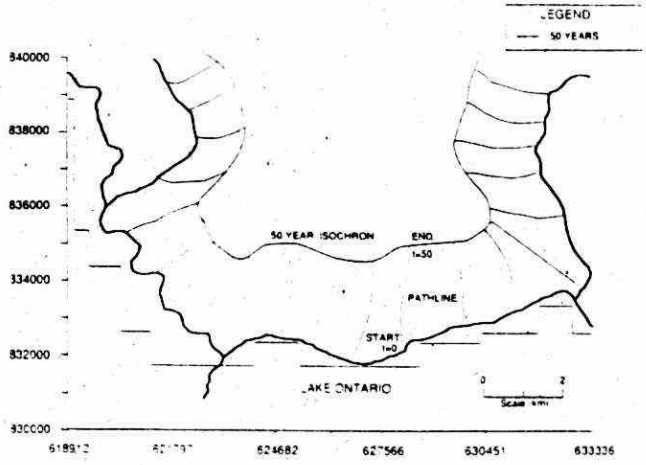
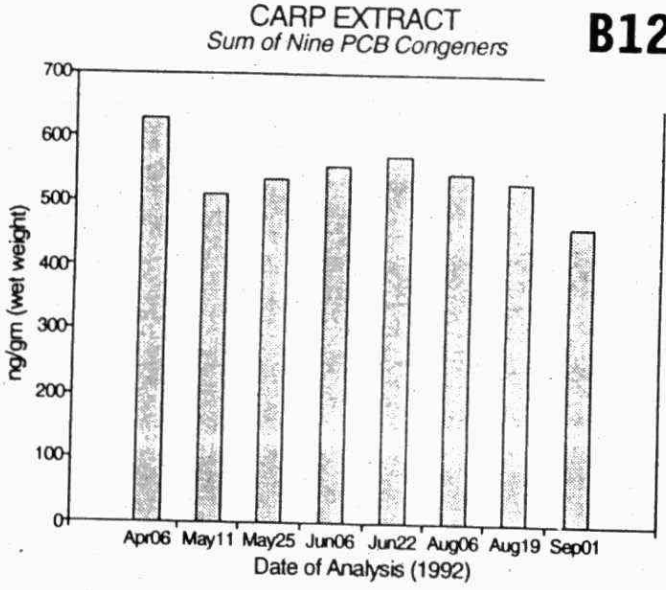


Figure 3 50 Year Contaminant Discharge Isochron Based on Pathlines
RETARDATION FACTOR, 1

V-5

Figure 1. Evaluation of carp CRM homogeneity and stability



B12

Table 1

1.	Product reformulation to eliminate the use of toxic materials that can become harmful pollutants,
2.	Process modifications that reduce the use of materials that become pollutants or reduce their losses to the environment,
3.	Redesign of existing equipment to reduce waste discharges by reducing leakage or increasing productivity,
4.	Recovery and recycle of waste residuals.

B14

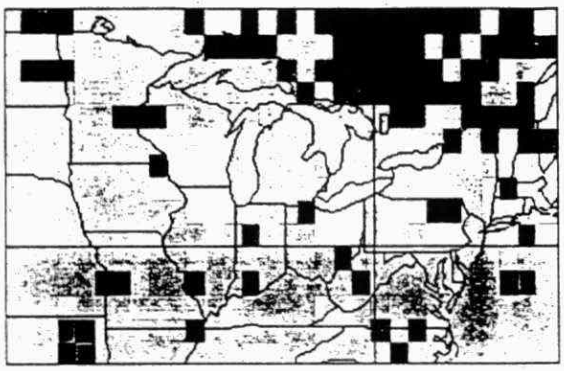


Figure 1. PSCF map of In in particles at Dorset, Ontario

C12

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Table 1. Summary of Basic Results

Measure	Standards	Trading	
		Lowest Cost	Lowest Emissions
Cost ($ millions)	$316	$187	$315
Emissions Reduced	55,900	55,900	68,100
Emissions Remaining (tonnes)	37,200	37,200	25,000
Average Cost per tonne ($)	$5,700	$3,300	$4,600

Note: Sums of components may not match totals due to rounding.
S o u r c e
NERA calculations.

B15

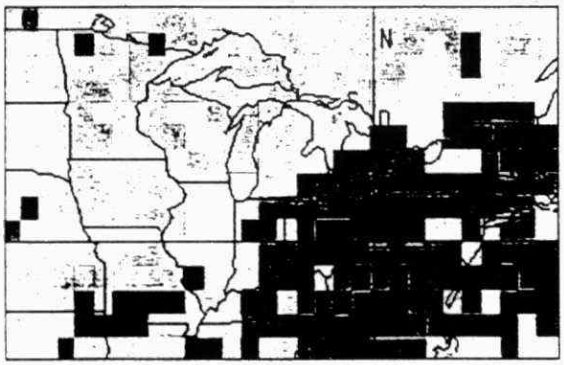


Figure 2. PSCF map of In in precipitation at Dorset, Ontario

Table 1: Summary of Column Data

Inocula (CFU)	Hydraulic Conductivity (m/s*10⁴)	Peak Relative Concentration (%)	Time of Peak Concentration (#PV's)	Cells Eluted (%)	Comments	
					macropore present	packing scheme
3.64*10⁸	1.9	0.49	4.7	0.08	no	B
3.64*10⁸	1.8	0.46	3.5	0.09	no	B
2.16*10⁸	7.6	78	1.7	16	no	A
2.16*10⁸	5.7	21	2.2	24	no	A
2.86*10¹⁰	6.4	14	0.82	0.93	no	A
1.86*10¹⁰	6.5	37	1.4	10	no	A
1.86*10¹⁰	11	91	1.5	27	no	A
6.5*10⁸	92	0.078	2.1	0	no	B
9.1*10⁸	93	0.30	5.0	0.04	no	B
1.0*10⁸	1200	250	1.2	39	yes	B

A18

Seasonal Variation of Isoprene at Fraserdale

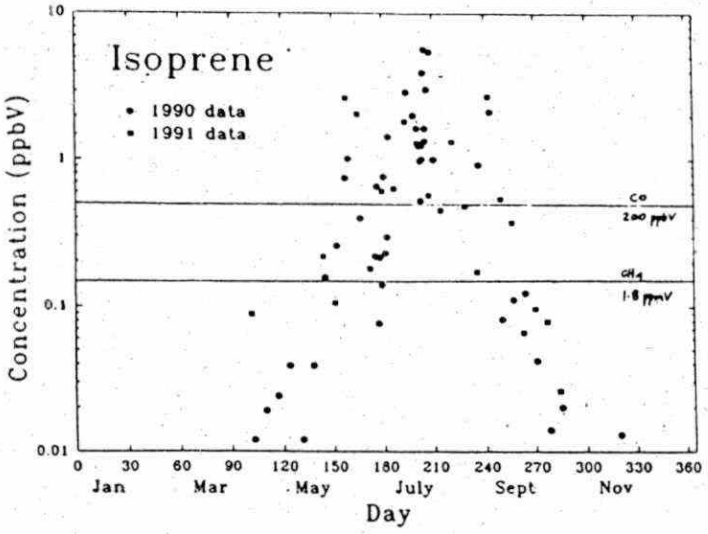


FIGURE 1

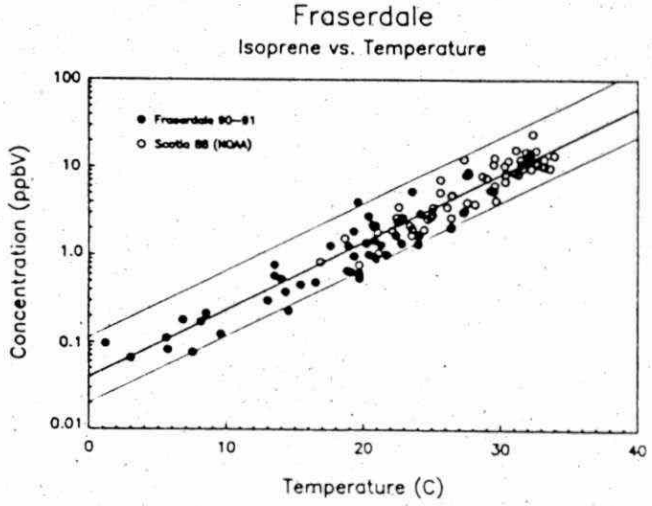


FIGURE 2

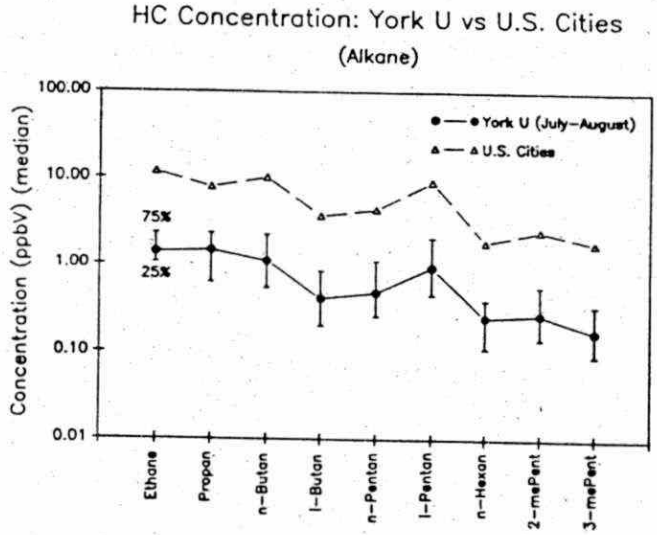


FIGURE 3

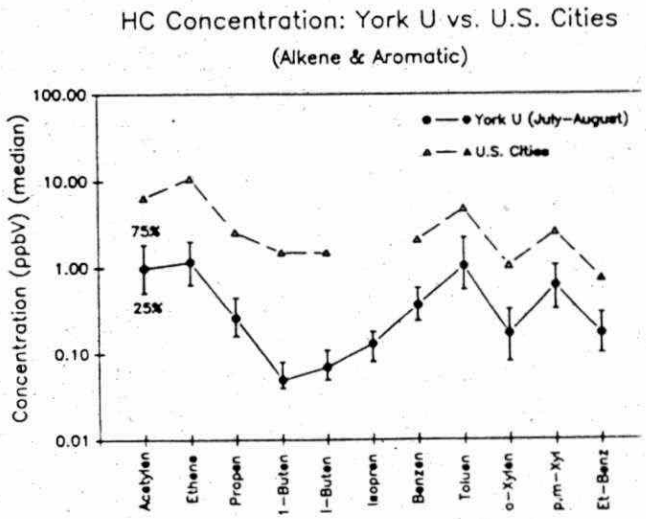


FIGURE 4

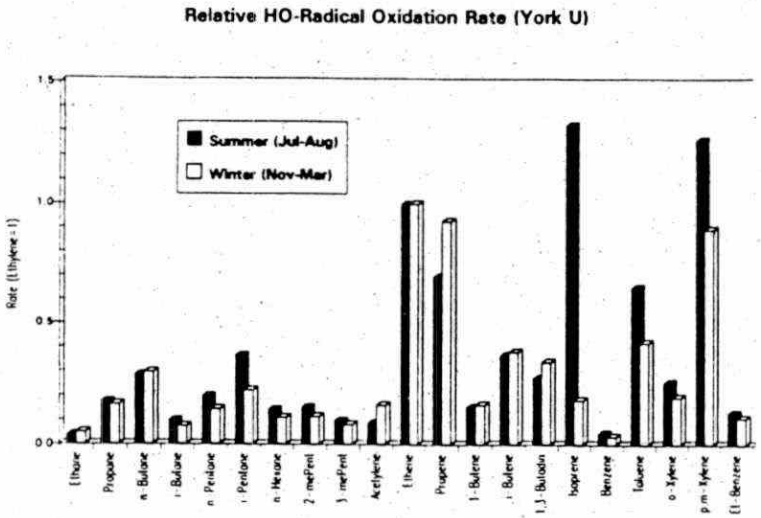


FIGURE 5

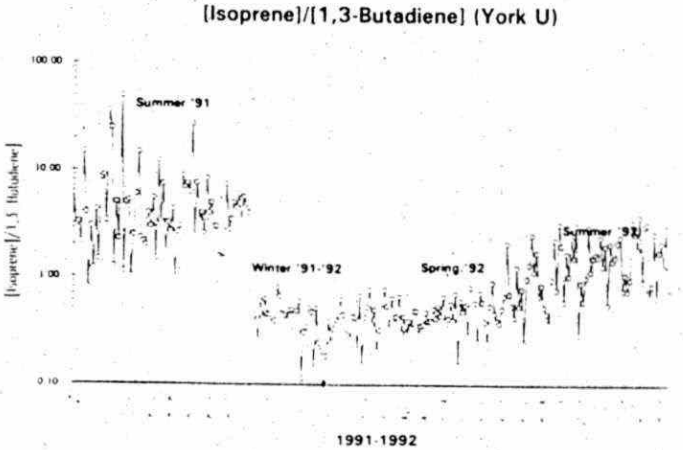


FIGURE 6

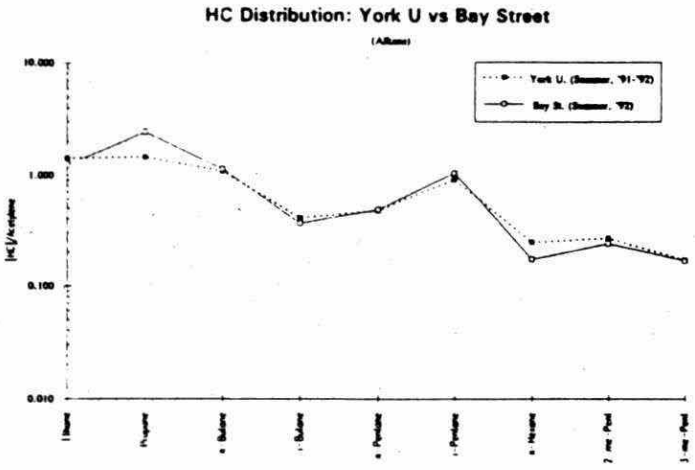


FIGURE 7

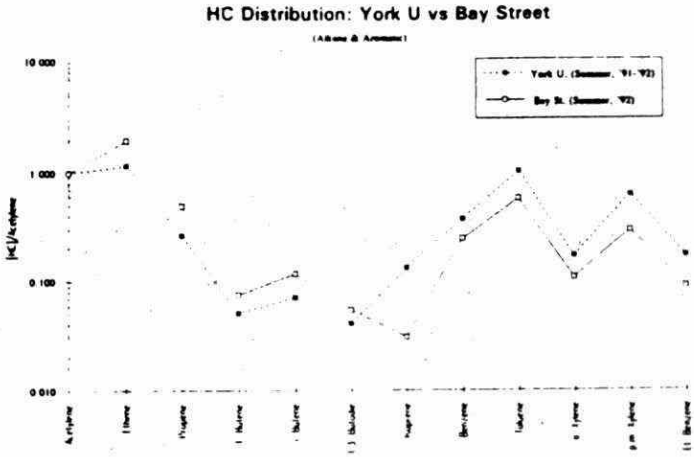


FIGURE 8

C17

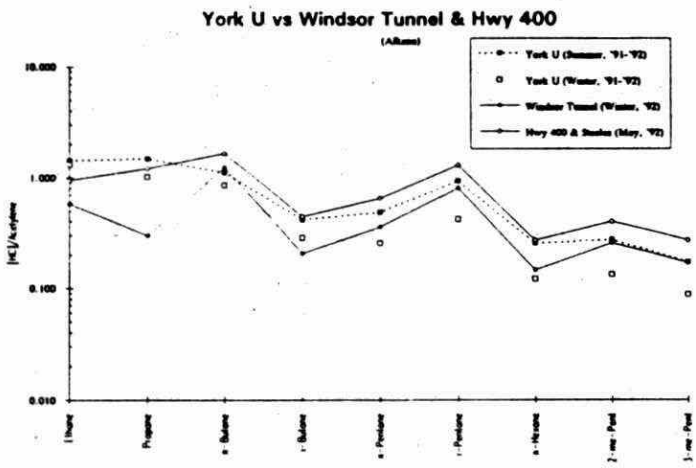


FIGURE 9

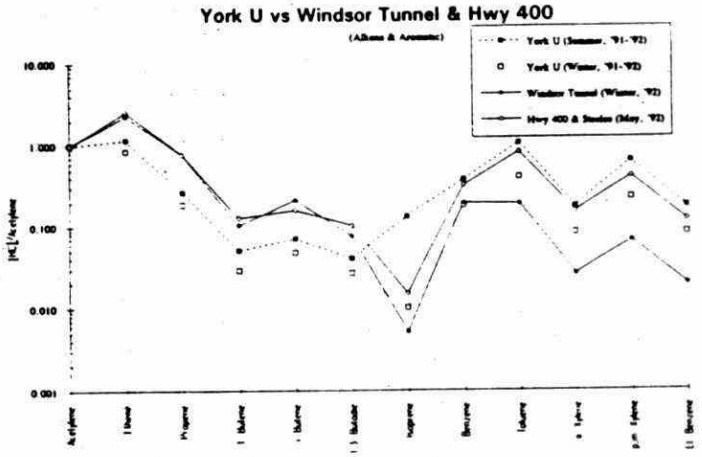


FIGURE 10

A21

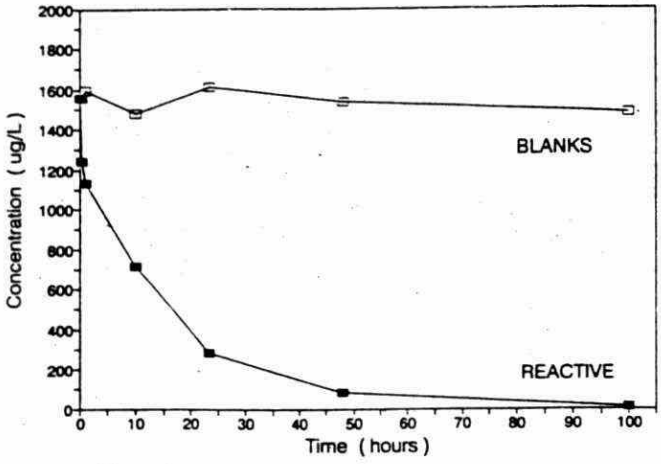


Figure 1:

Concentration of TCE blanks and reactive samples in $\mu g/L$ versus time in hours.

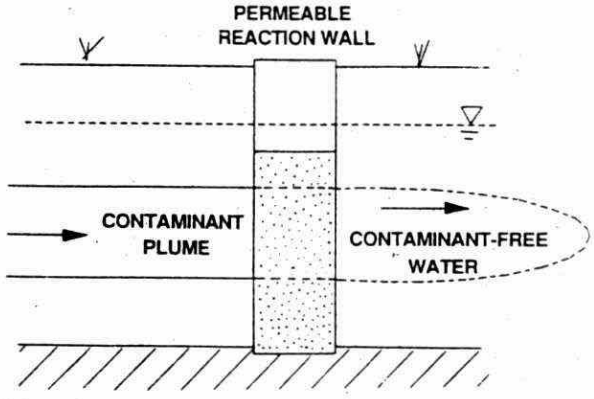
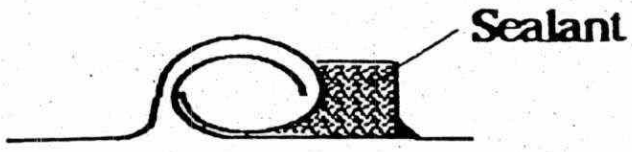
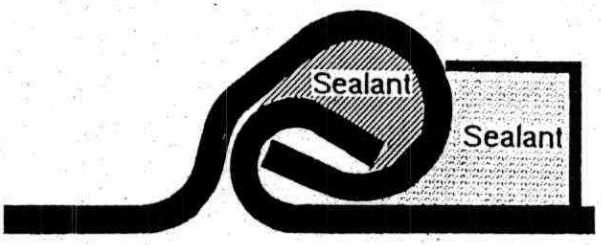


Figure 2:

Contaminant plume being remediated as it moves passively through a permeable reaction wall.

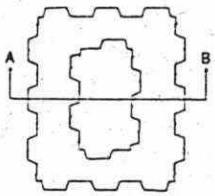


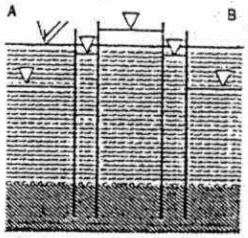
Internal Cavity Sealable
Joint Sheet Piling

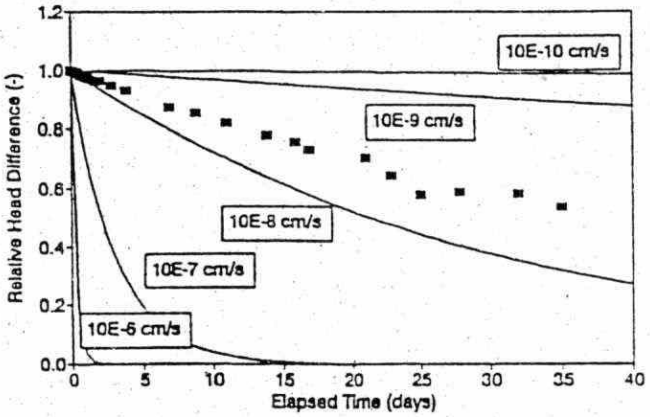


Steel Angle

Dual Cavity Sealable
Joint Sheet Piling





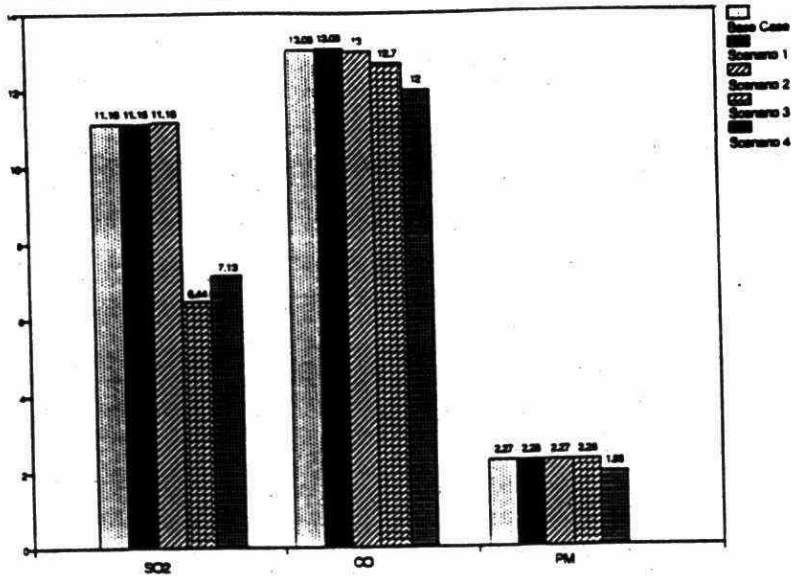


A22

THE FIVE PROJECTIONS	
Scenario	**Description**
Base Case	Standard Informetrica (Fall 1991) projection covering annual GDP, employment, investment and capital stock projection from 1991 to 2010.
1. International Growth	Increased economic expansion in Europe and the U.S. creates higher demands for Ontario exports.
2. Labour Productivity	Major investments are made by government and private firms to raise labour productivity.
3. Environmental Initiatives	Thirty billion (1991$) is invested by public and private interests and technology is focused on environmental programs.
4. Industrial Shift Case	Industry shares are altered to simulate the effects of extended reductions in relative shares for raw material and primary industries while service industries continue to expand.

B18

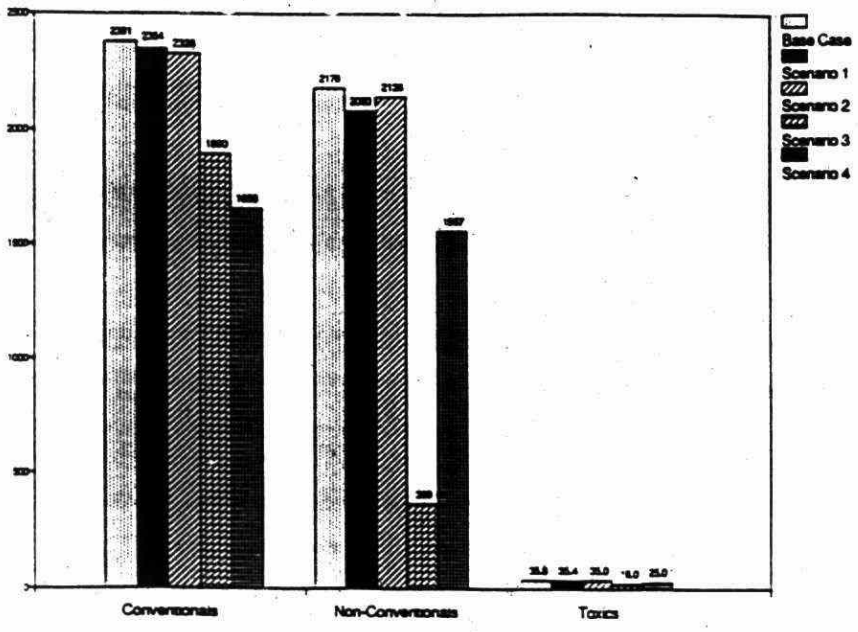
Exhibit 1: Air Emissions - SO_2, CO, PM
Growth-Adjusted Emissions (t per MSGDP; Year 2010)



Difference from Base Case (Percent Change)			
	SO_2	CO	PM
Scenario 1	-0.1	+0.3	+0.7
Scenario 2	+0.1	-0.4	+0.3
Scenario 3	-42.3	-2.4	-0.6
Scenario 4	-36.1	-8.5	-12.6

B18

Exhibit 2: Industrial Water Discharges
Growth-Adjusted Discharges (kg per MSGDP)



Difference from Base Case (Percent Change)			
	Conventionals	Non-Conventionals	Toxics
Scenario 1	-1.1	-4.4	-1.1
Scenario 2	-2.2	-1.8	-2.0
Scenario 3	-20.6	-83.0	-48.9
Scenario 4	-30.4	-28.5	-30.6

C20

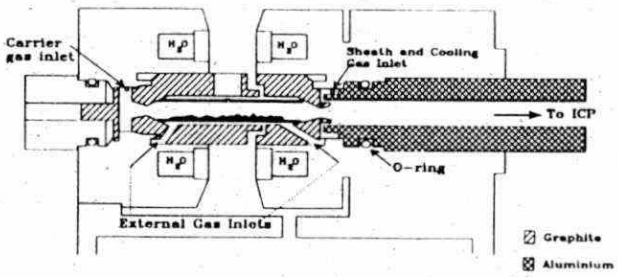


Table 1: Performance Specifications of Various Consumer Market Dry Cells.

	Heavy Duty	*Primary Alkaline*	*NiCd*	*NiMeH*	*RAM Mercury Free*
>75% Charge Retention at 20C [years]	*2-3*	*>4*	*0.1-0.2*	*<0.1*	*2-3*
Life Cycle Depending on the Depth of Discharge	*1*	*1*	*300-1000*	*300-1000*	*25-250*
Nominal Discharge Capacity [mAh]	*500*	*2500*	*750*	*1100*	*1500*
Minimum Continuous Recommended Discharge Time [hours]	*5*	*5*	*0.5*	*0.5*	*5*	
Cost: Manufacturing	*Low*	*Medium*	*High*	*Very High*	*Medium*
Cost: Operating	*High*	*High*	*Low*	*Low*	*Low*
Environmental Issues: Resource preservation	*No*	*No*	*Yes*	*Yes*	*Yes*
Disposal Issues Materials of Concern	*Some*) Hg*	*Some*) Hg*	*Yes Cd, Ni*	*Some Ni, Cr, V*	*Few*

*) Recently mercury free cell designs have become available.

D16

Table 2: IEC, Primary Alkaline and AA RAM Cell Performance Standards.

DISCHARGE TEST	LOAD CONDITION	IEC MINIMUM AVERAGE	Mercury Free RAM	PREMIUM PRIMARY 0.025%Hg
TRANSISTOR RADIO [hrs]	*75Ω 4H/D*	*100*	*89*	*144*
WALKMAN [hrs]	*10Ω 1H/D*	*11.0*	*13.8*	*17*
MOTOR & TOYS [hrs]	*3.9Ω 1H/D*	*5.8*	*5.8*	*7.0*
PULSE TEST [Flashes0 (PHOTOFLASH)	*3Ω 15/45Sec*	*320*	*417*	*543*
PERFORMANCE COMPARISON [%]		*100*	*111* *76*	*100*

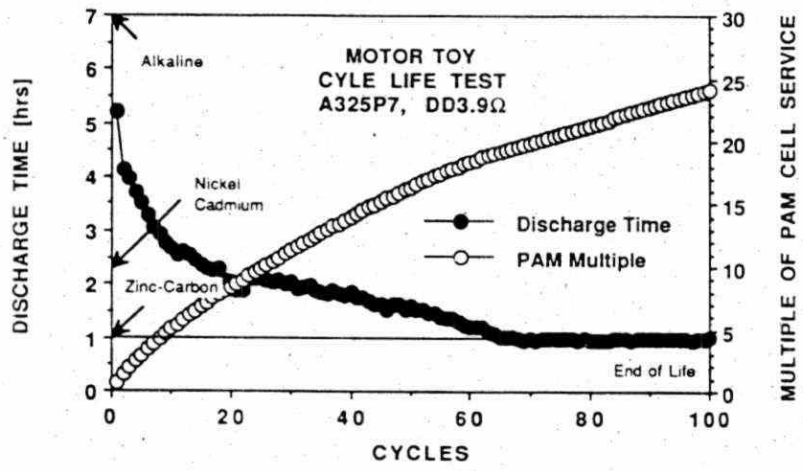


Figure 1: Cycle Life Test of Mercury Free RAM Cells on the Motor Toy Load (3.9Ω) to a Cut Off of One Hour Operating Time.

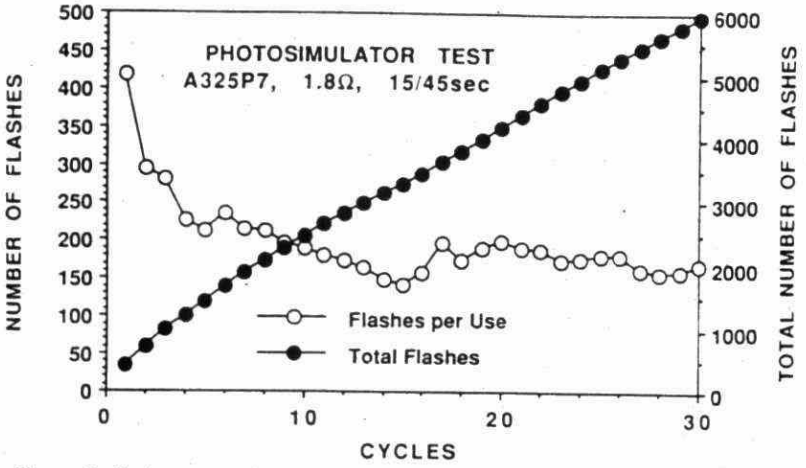


Figure 2: Performance of Mercury Free RAM Cells on the Photosimulator Test (1.8Ω, 15 sec Pulse, 45 sec Rest, Continuous to 0.9V, 12 hour recharge).

D16

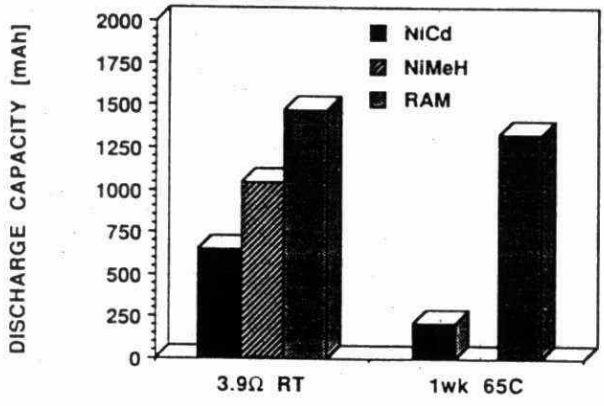


Figure 3: Charge Retention Comparison of Nickel-Cadmium, Nickel-Metal Hydride and of Mercury Free RAM Cells (Discharge: 3.9Ω cont. to 0.8V).

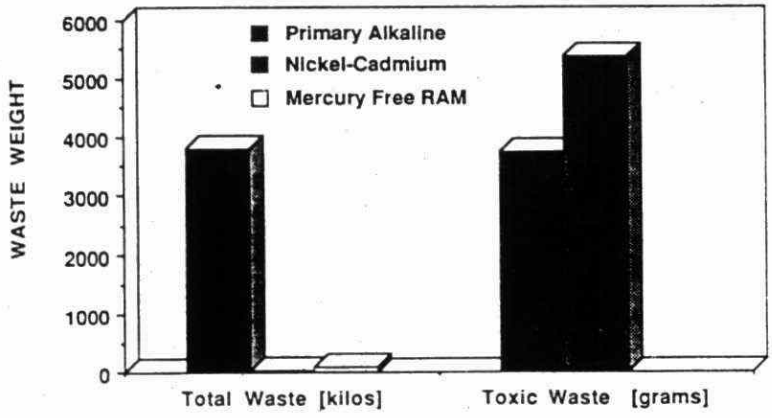


Figure 4: Total and Toxic Waste Created by Primary Alkaline, Nickel-Cadmium and Mercury Free RAM cells in a Walkman Application (1000 Units Containing two AA cells each, Operating for 4 Hours a Day Over a Period of a Year).

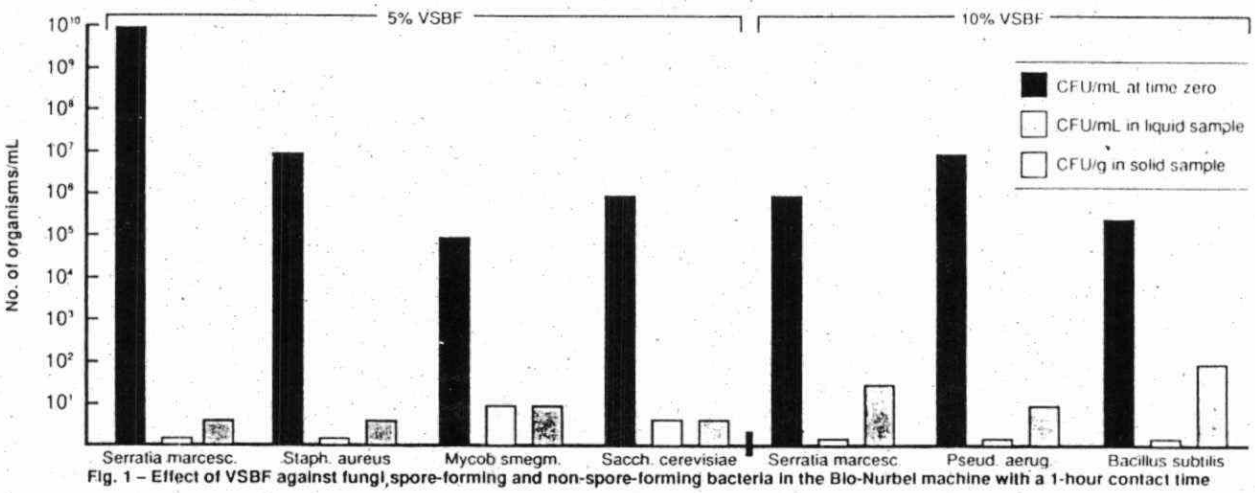


Fig. 1 – Effect of VSBF against fungi, spore-forming and non-spore-forming bacteria in the Bio-Nurbel machine with a 1-hour contact time

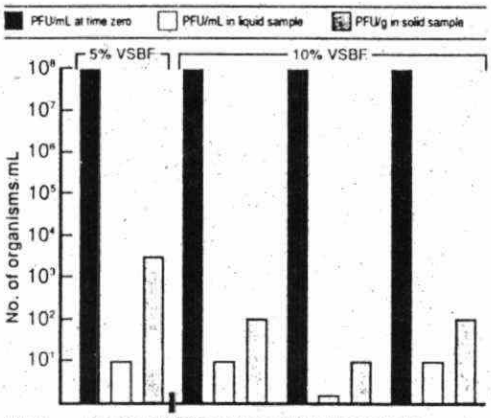


Fig. 2 – Effect of VSBF against MS-2 Phage in the Bio-Nurbel machine with a 1-hour contact time

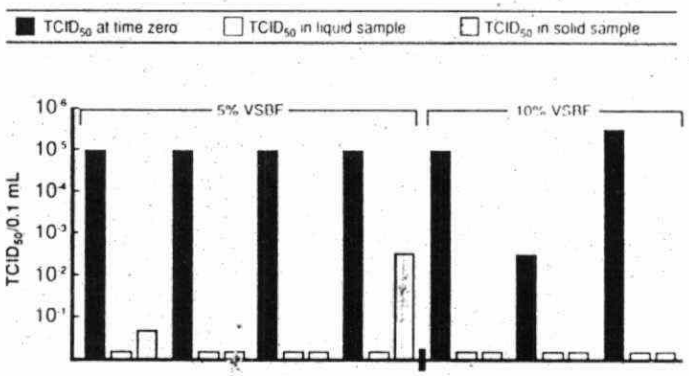


Fig. 3 – Effect of VSBF against Poliovirus Type 1 in the Bio-Nurbel machine with a 1-hour contact time

D18

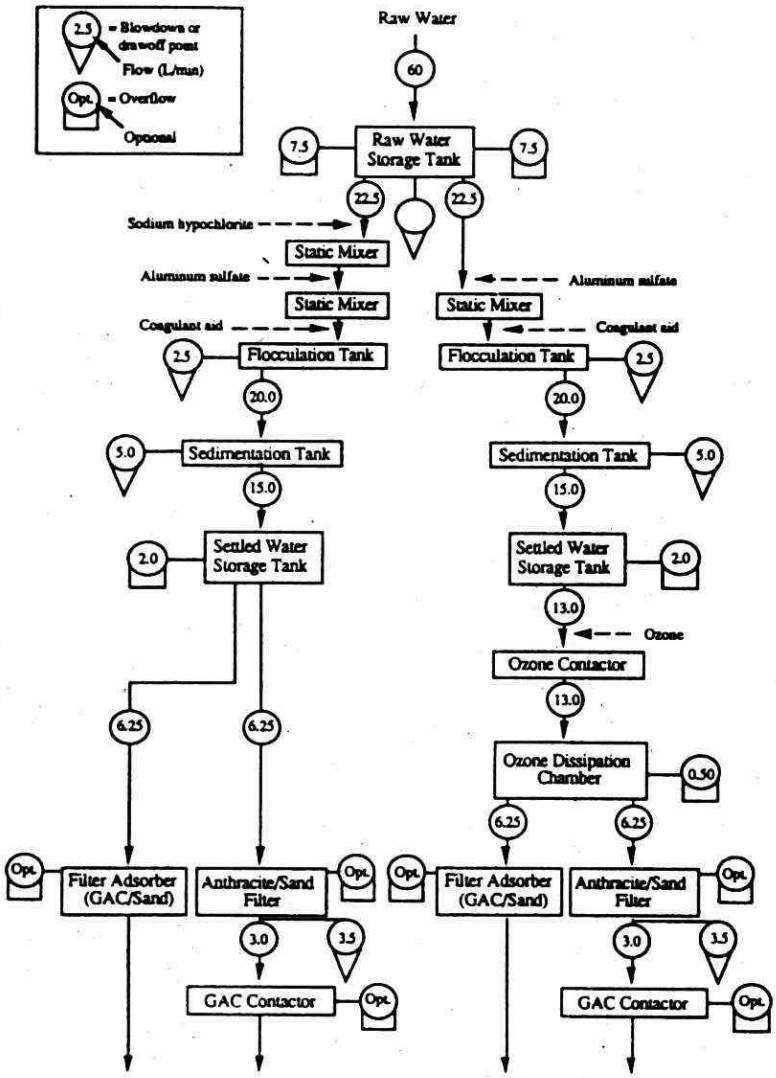
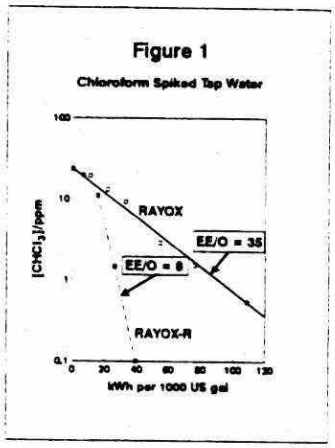
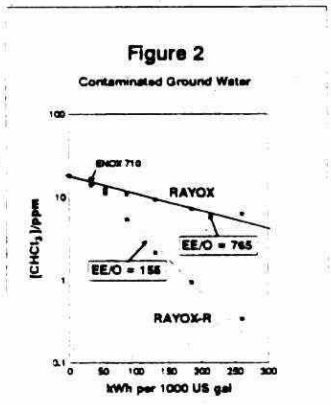
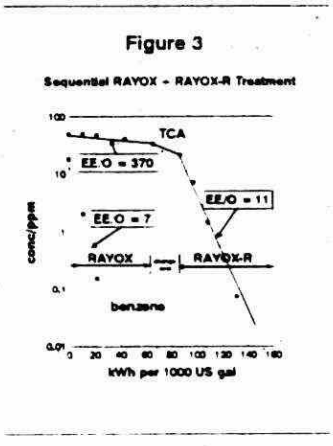


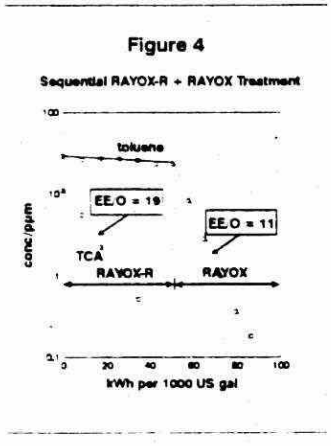
Figure 1. Pilot Plant Configuration and Flow Conditions for Experiment 1.4

AP1









AP2

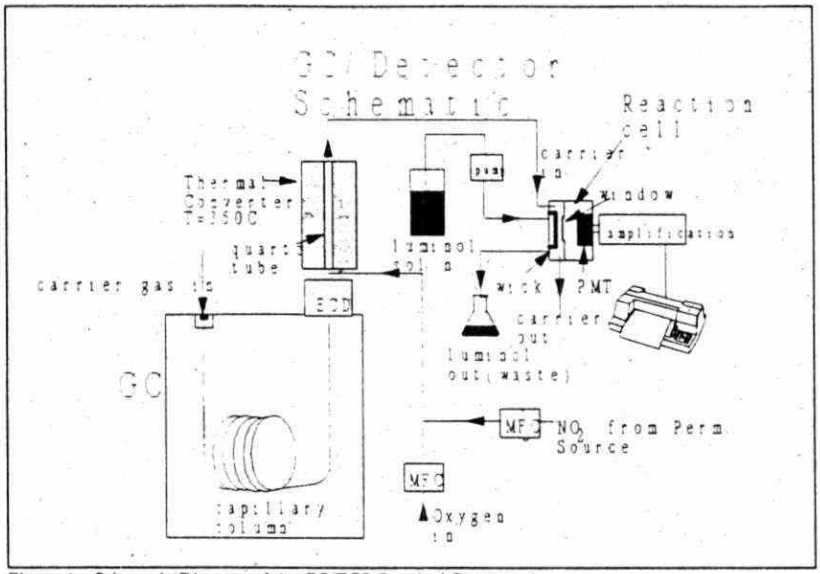


Figure 1. Schematic Diagram of the GC/ECD/Luminol Detector.

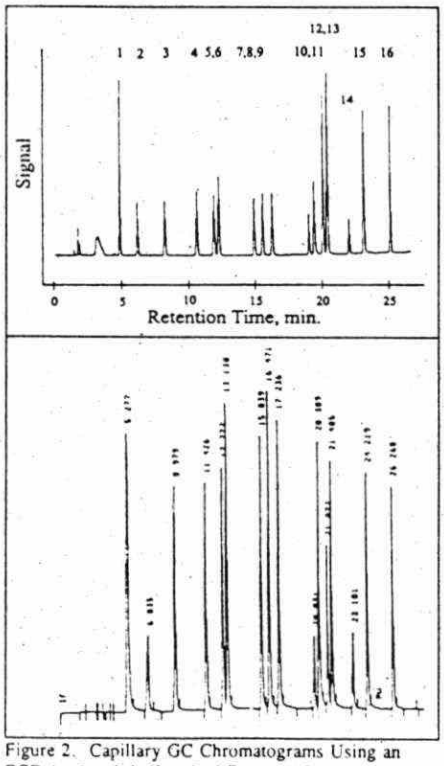
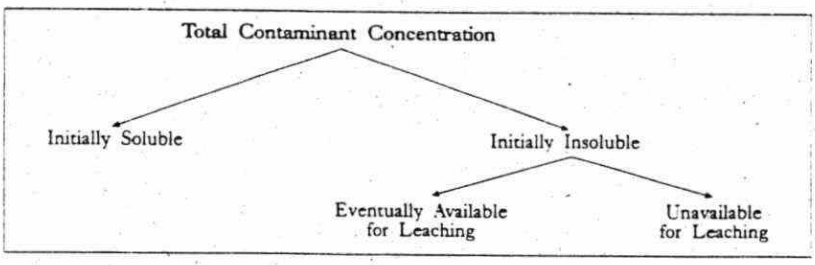


Figure 2. Capillary GC Chromatograms Using an ECD (top) and the Luminol Detector (bottom)

AP3

Figure 1: Contaminant Decision Tree



AP4

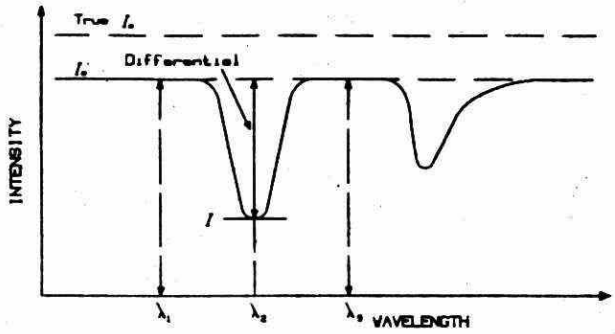


Figure 1: Basis of differential optical absorption spectroscopy

BP4

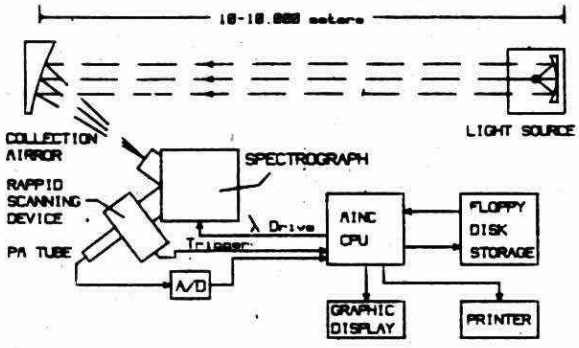


Figure 2: Schematic diagram of DOAS spectrometer

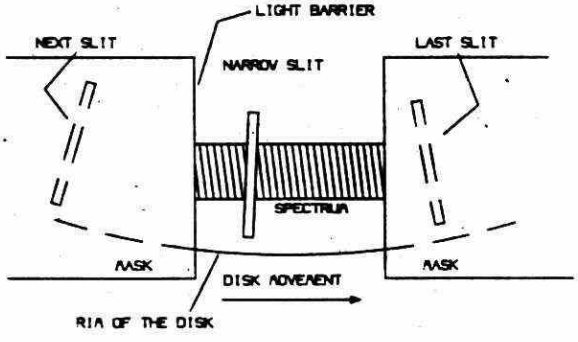


Figure 3. Schematic diagram of the slotted disk in the rapid scanning device

MFC Vers. 1.2zt IUPHD
Region: 3 Spectrum:
Next File Out: 0000001 In: 0000000
Mem: 109008

04.09.92 13:58
Min: 9.980963e-01 Max: 1.001489e+00
Avg: 1.000000e+00 Delta: 3.393e-03
Y-Scale: 90% Offs: 5% Disp: loc
Ch 183 Ct 9.984699e-01 Wl: 363.8nm

3n

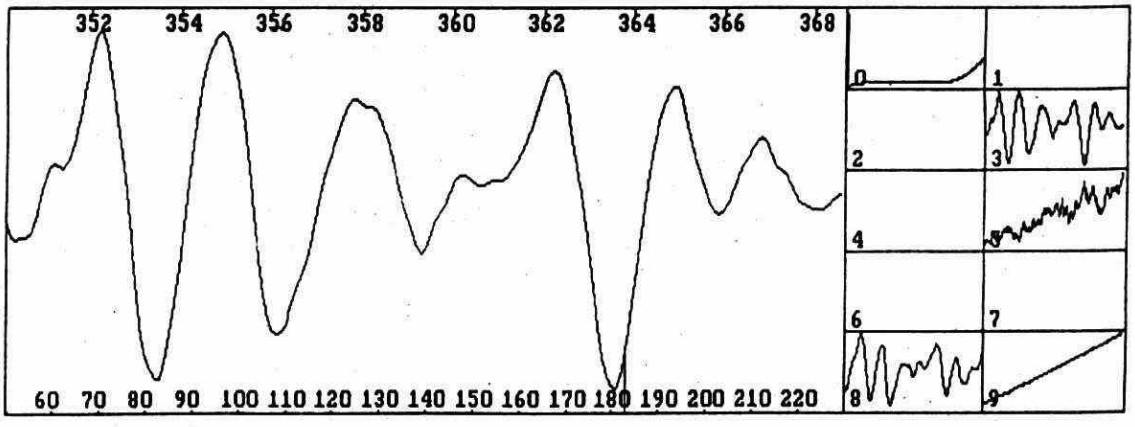


FIGURE 4: The spectrum of 7 ppb NO_2 in ambient air in the 345-370 nm region for a path length of 1300 m and an acquistion time of 3.5 minutes. The reference NO_2 spectrum is shown in Panel 8. The background, and raw spectra are shown in Panels 5 and 9 respectively.

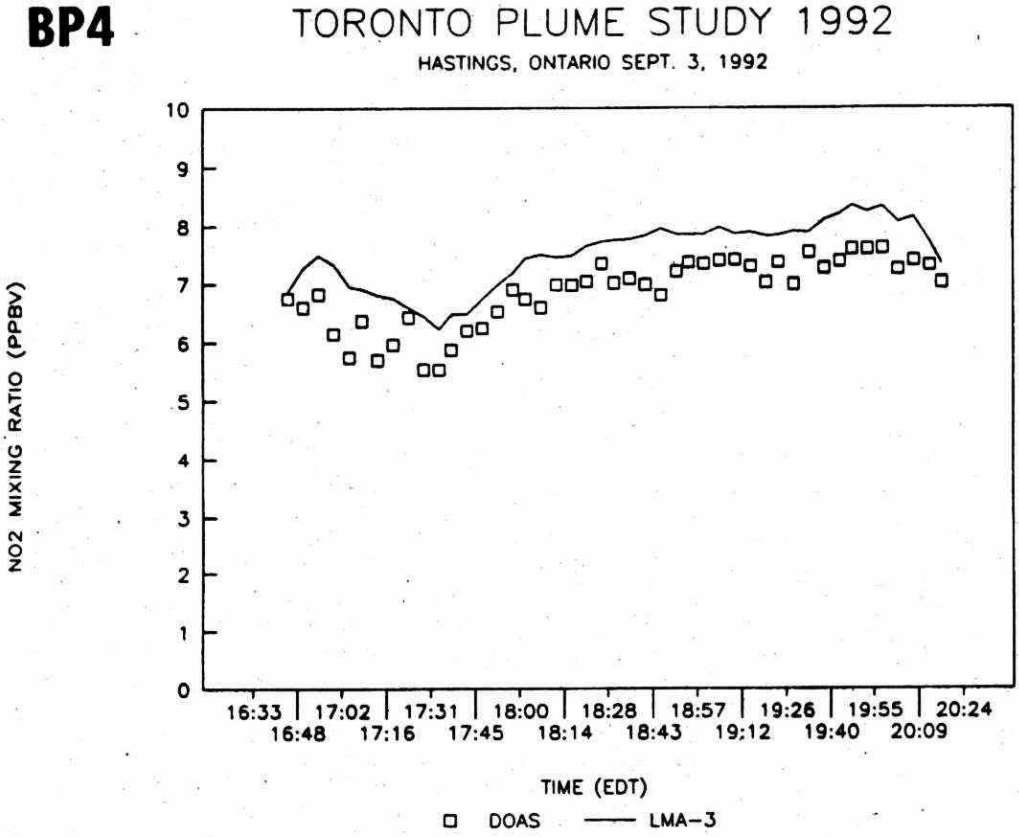


Figure 5: Comparison of NO_2 measured at Hastings, Ontario by Differential Optical Absorption Spectroscopy and a LMA-3 Chemiluminscence analyzer. Each DOAS data point represents the average of 30,000 scans acquired over a 3.5 minute period. LMA-3 valves were obtained every second and averaged into 3.5 minute samples. Linear regression analysis indicates a consistant 9% difference between the two data sets.

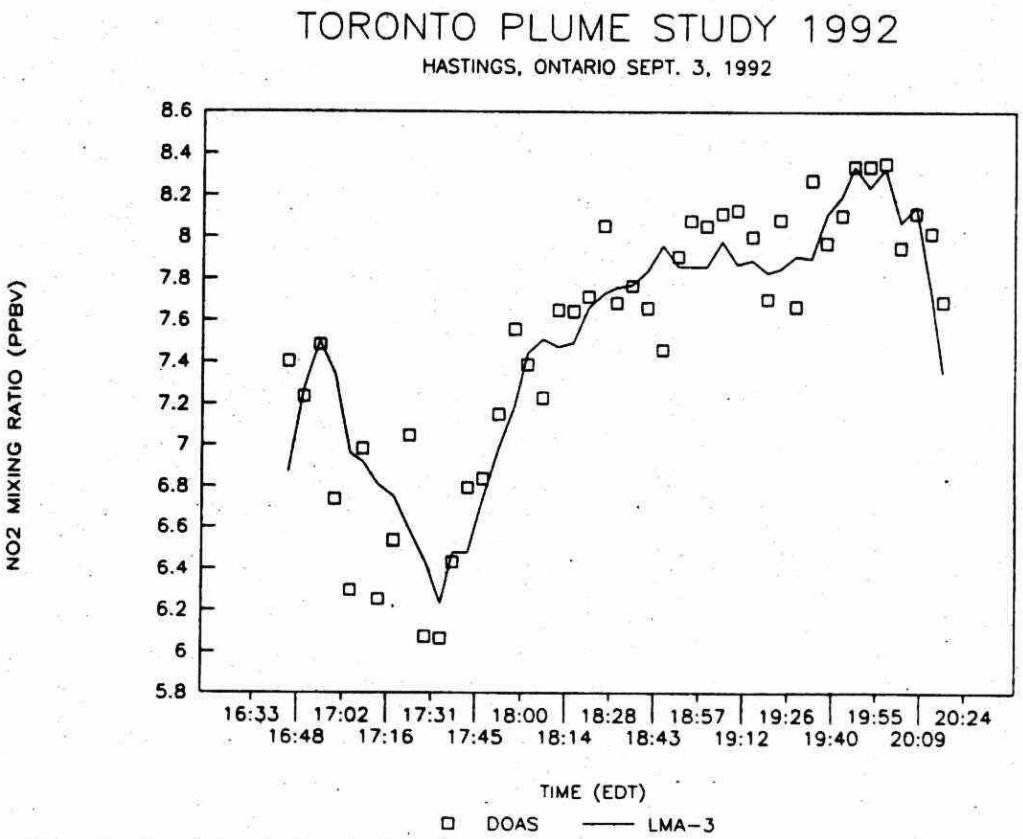
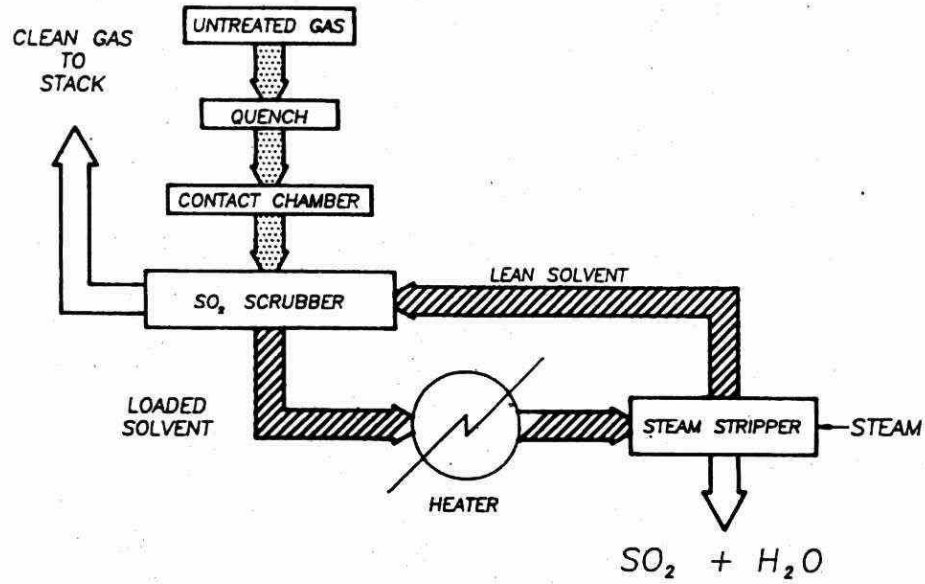


Figure 6: Expanded scale for the data shown in Figure 5. DOAS data has been increased by 9%, the average difference between the LMA-3 data and the DOAS data during the measurement period.

Figure 1.

Typical F.G.D. Process Flowsheet

BP5



BP13

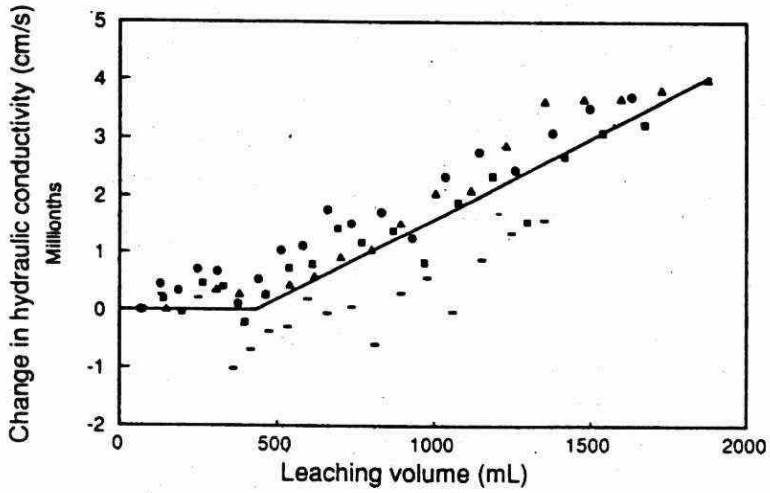


Figure 1. Change of hydraulic conductivity with leaching volume

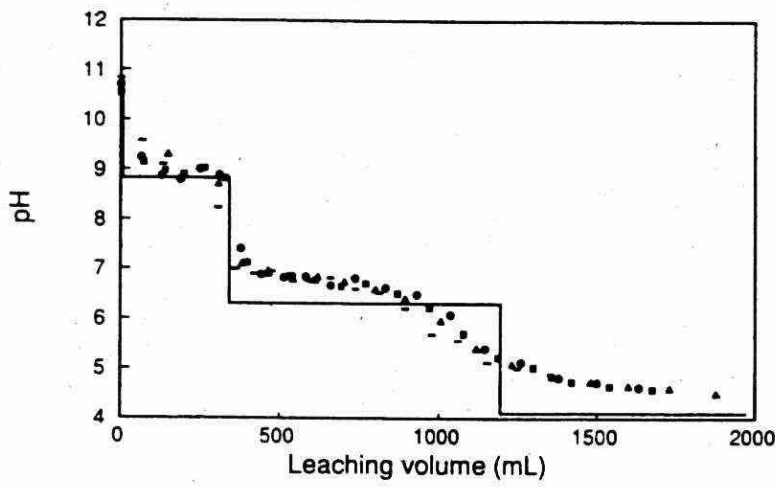
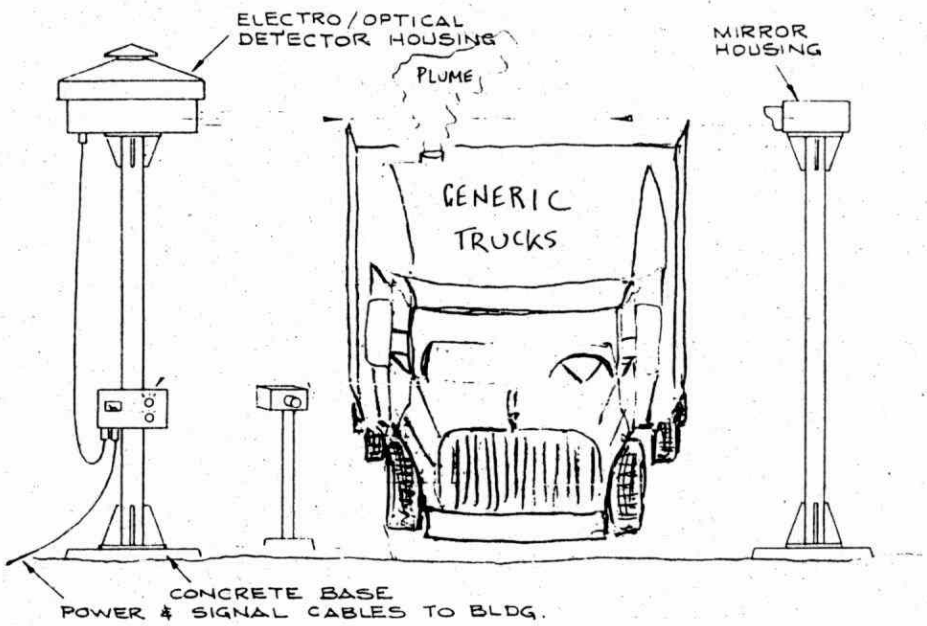


Figure 2. Variation of pH in the effluent leachate

FIGURE 2 TURNER, R.D ET237AP SEPT./92

"CONCEPTUAL INSTRUMENT IMPLEMENTATION"



BP6

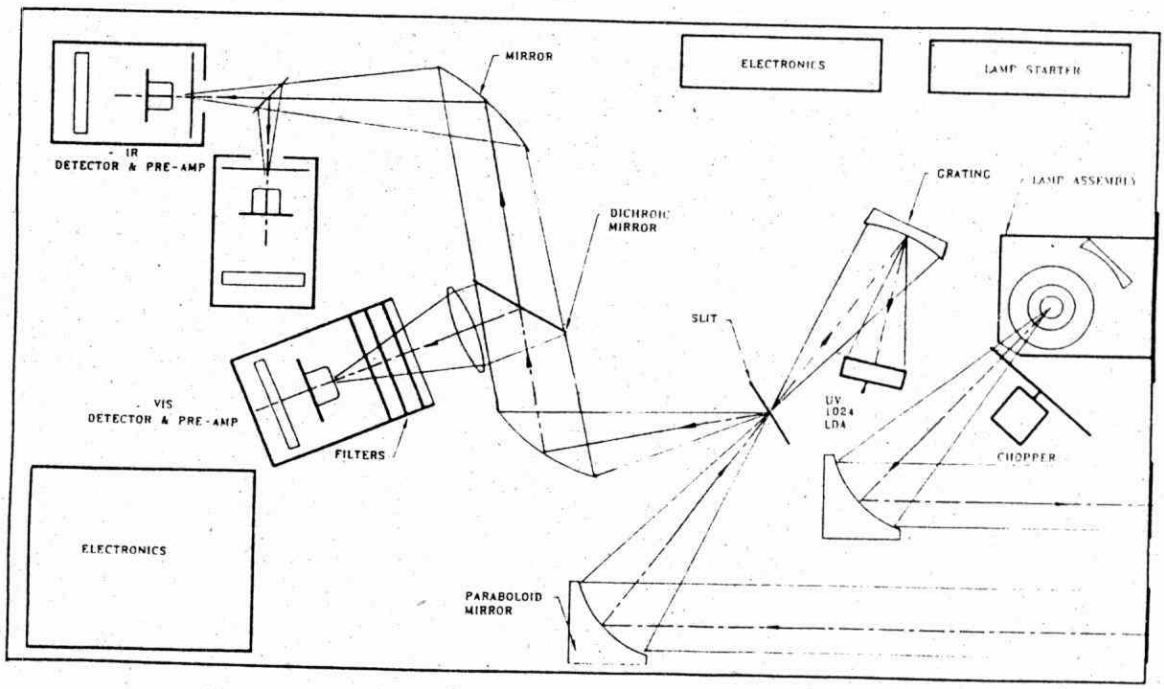


FIGURE 1 TURNER, R.D ET237AP SEPT./92

"SCHEMATIC OF THE PROPOSED OPTICAL SYSTEM"

FLOW CHART OF DATA ACQUISITION SYSTEM

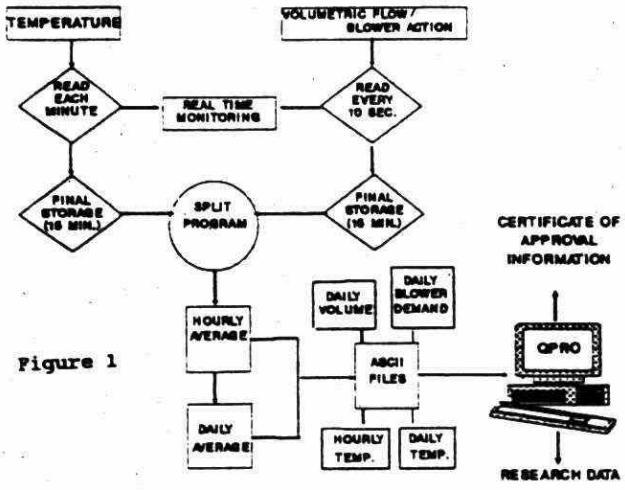
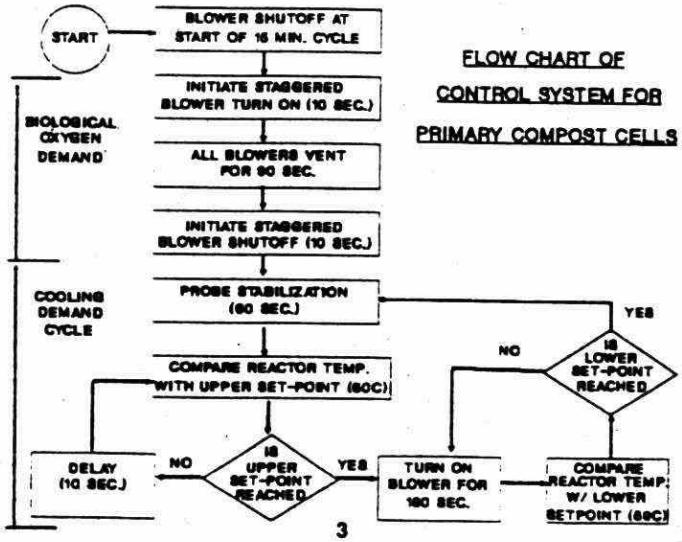


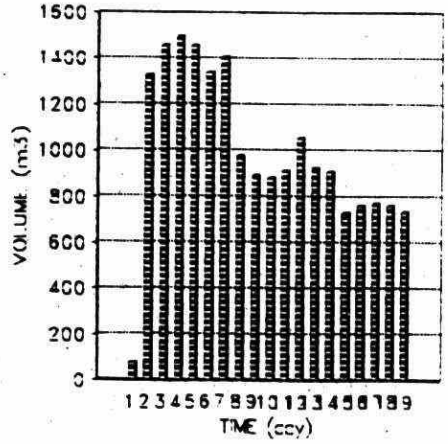
Figure 1



FLOW CHART OF CONTROL SYSTEM FOR PRIMARY COMPOST CELLS

3

VOLUME OF AIR ENTERING PRIMARY REACTORS



BLOWER CYCLE FOR PRIMARY REACTORS

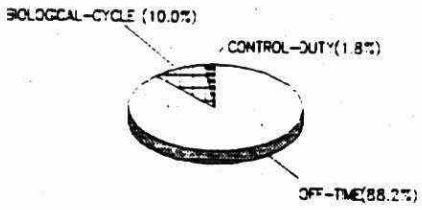
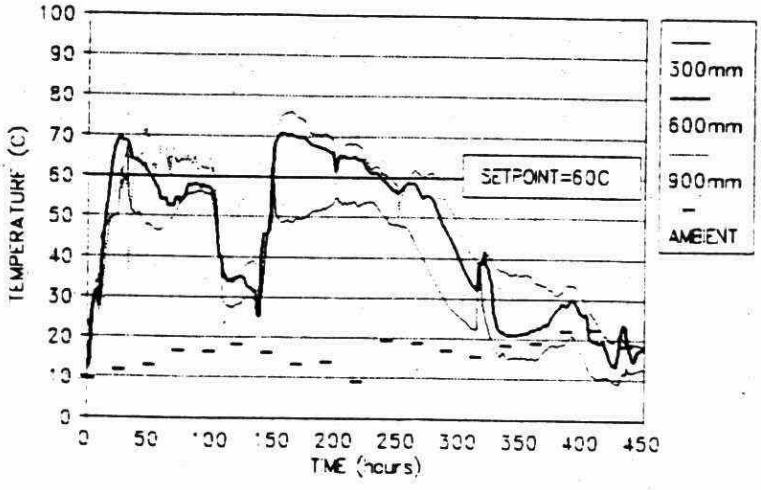


Figure 3

AP11

BATCH 822 TEMPERATURE HISTORY
PRIMARY REACTOR PHASE (MAY 1992)



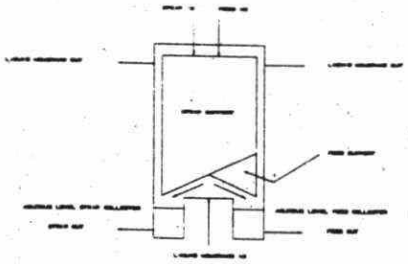


Fig. 1 Configuration of flow in the liquid membrane pertraction unit.

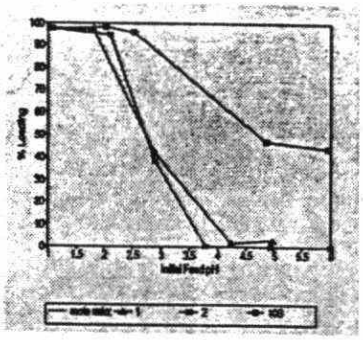


Fig. 2. Cr(VI) loading vs pH for various sulphate/chromate mole ratios. Organic: 5 v% TOA, 4 v% 2-ethyl-1-hexanol in kerosene. Feed: 200 ppm Cr(VI) as potassium dichromate; sulphate adjusted with potassium sulphate.

BP14

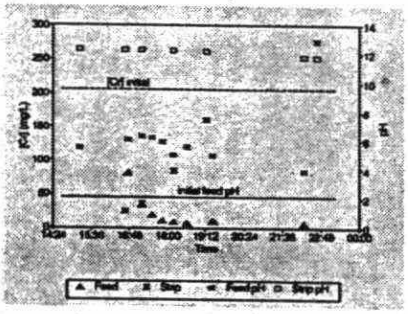


Fig. 3 Pertractor outlet pH and chromium concentration versus time. Total feed and strip mass flow rates (residence time in brackets) were 2.21 g/min (0.9 h) and 0.85 g/min (4.5 h), respectively.

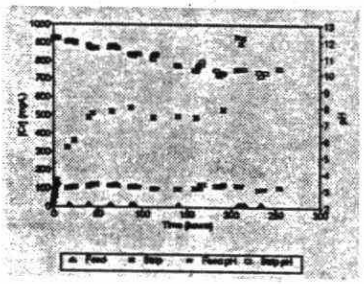


Fig. 4. Pertractor outlet pH and chromium concentration versus time. Total feed and strip mass flow rates (residence time in brackets) were 1.5 g/min (1.3 h) and 0.5 g/min (7.7 h), respectively.

AP15

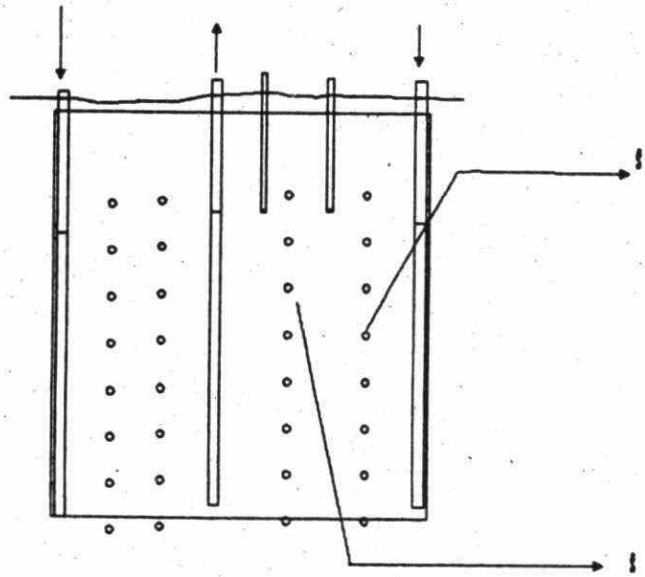
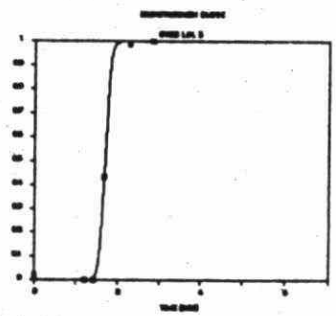
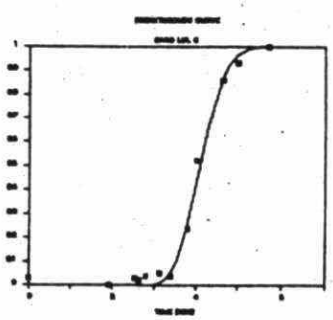


Figure 2: Crossection through permeable wall



Typical breakthrough at 0.6 m from injection well.



Typical breakthrough at 1.3 m from injection well.

AP15

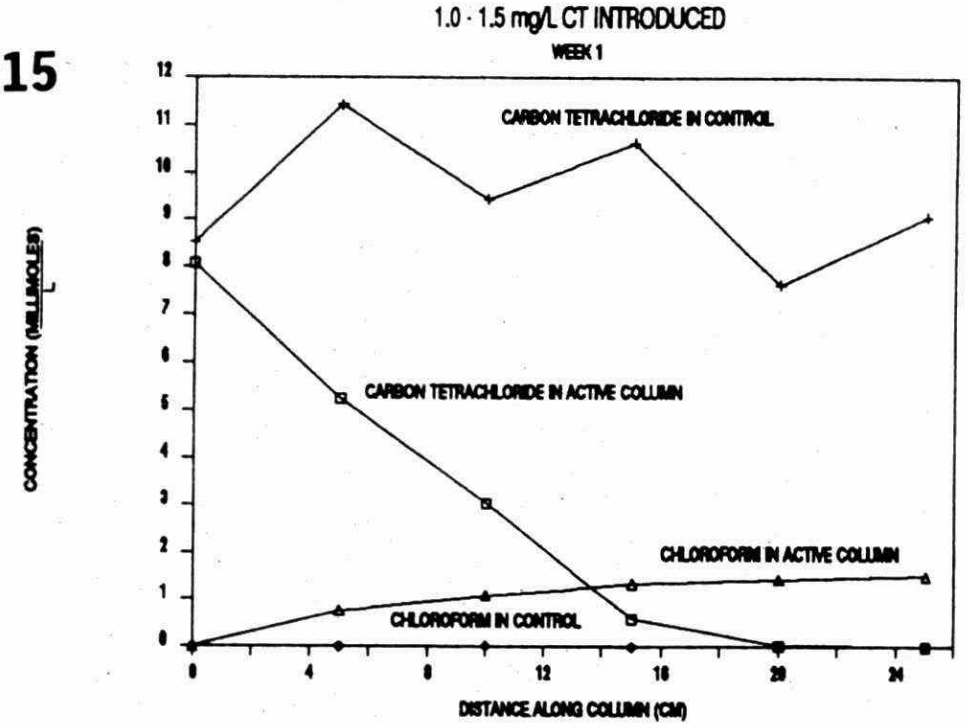


Figure 1: CT and CF profiles for active and control columns

AP16

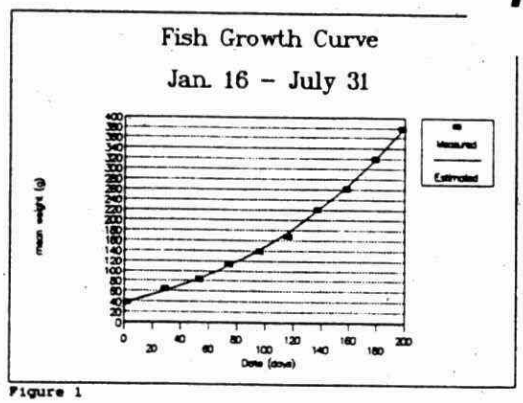


Figure 1

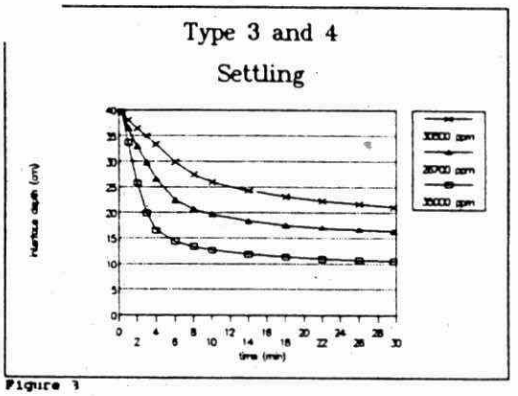


Figure 3

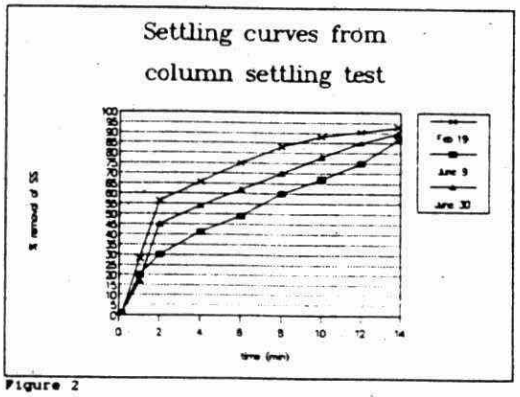


Figure 2

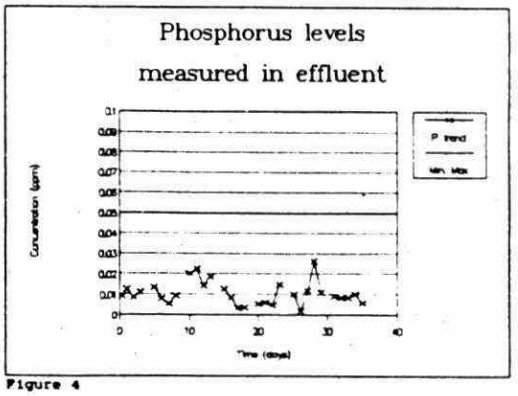


Figure 4

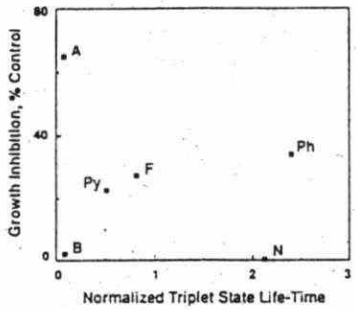


FIG. 2-Growth inhibition as a function of the triplet state lifetimes of PAHs. The triplet state lifetimes in Table 1 were normalized to their mean (normalized value = data point ÷ mean of the data set). Toxicity of the chemicals applied in intact form, as measured by growth inhibition, was plotted as a function of the normalized triplet state lifetime.

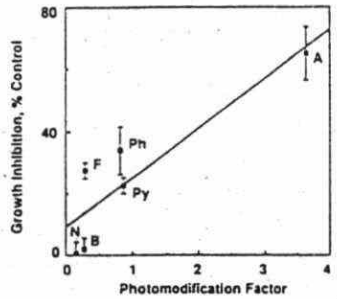


FIG. 3-Growth inhibition as a function of the photomodification rates of PAHs. Toxicity of the chemicals applied in intact form, as measured by growth inhibition, was plotted as a function of the normalized photomodification rate. The line was generated by simple linear regression.

BP19

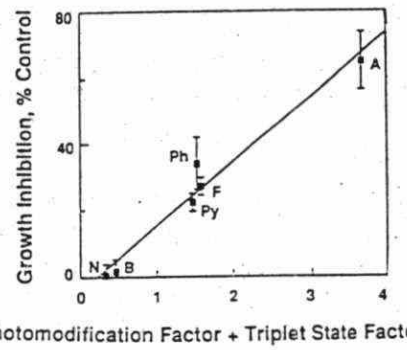


FIG. 4-Growth inhibition as a function of the sum of the photomodification rates and photosensitization factors of the PAHs. The normalized photomodification rate was used as in Fig. 3 and the photosensitization factor was generated according to equation [1]. The two factors were summed without further mathematical manipulation. Toxicity of the chemicals applied in intact form (Table 1) was plotted as a function of this summed photochemical factor.

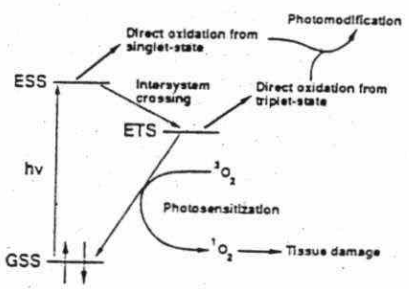


FIG. 1-Jablonski diagram for ground and excited states of a chemical. Absorbance of a photon of energy $h\nu$ elevates an electron from the ground singlet state (GSS) to an excited singlet state (ESS). From there it can react directly, or cross to the excited triplet state (ETS). In the triplet state, it can be oxidized or transfer its energy to oxygen, forming excited singlet oxygen ($^1O_2$).

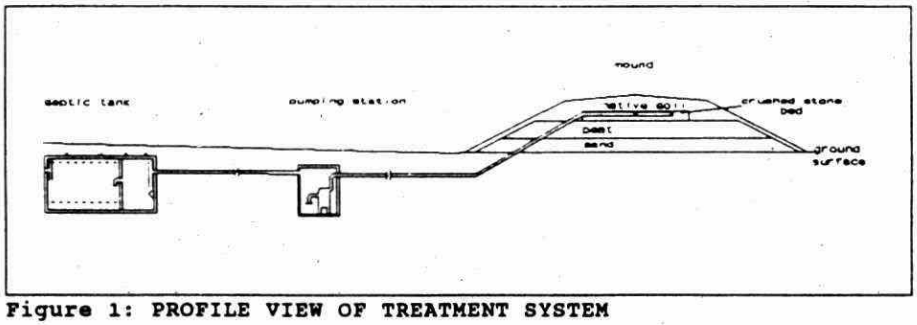


Figure 1: PROFILE VIEW OF TREATMENT SYSTEM

BP16

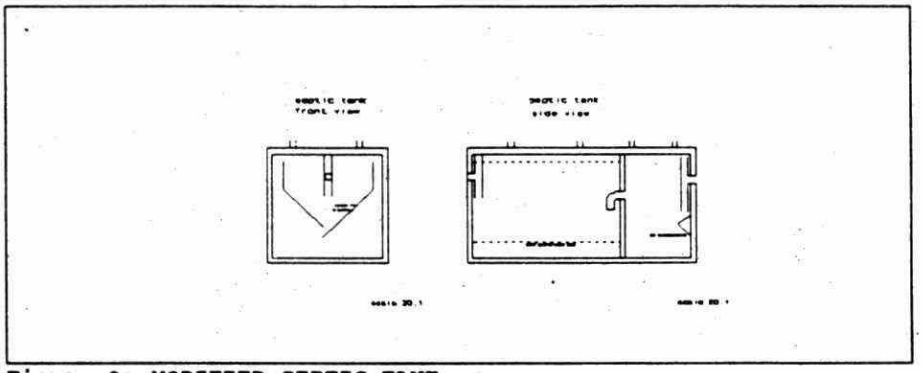
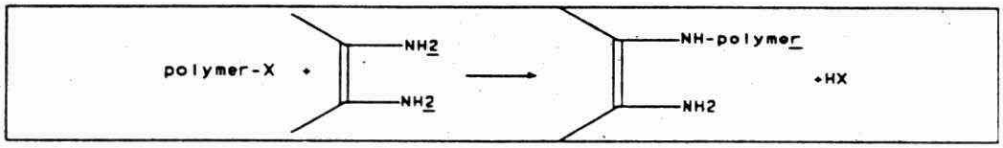
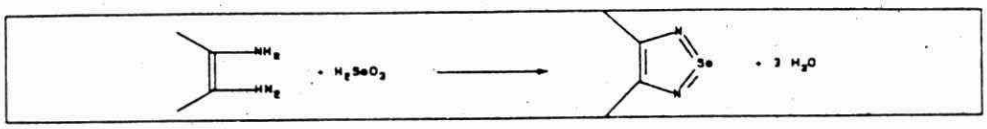


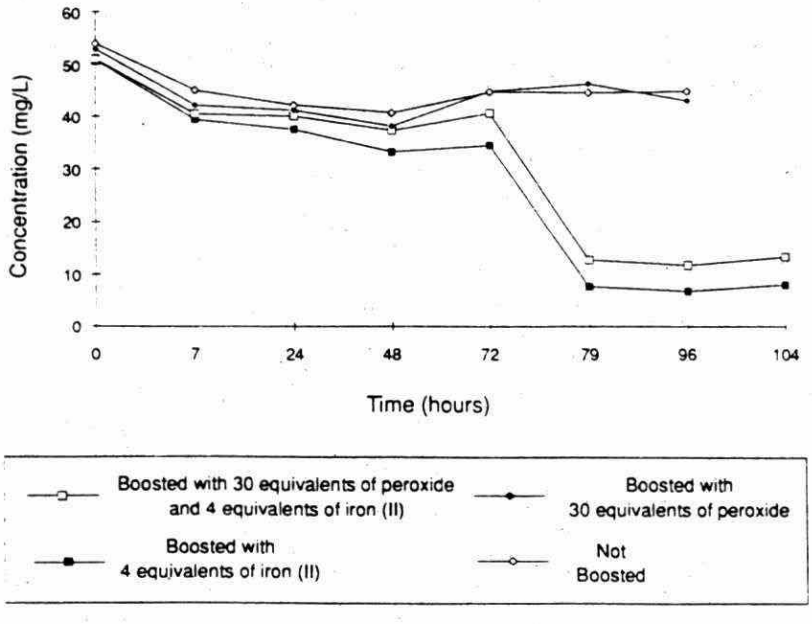
Figure 2: MODIFIED SEPTIC TANK

AP17





AP25



Reaction Mixtures were boosted after 72 hours.

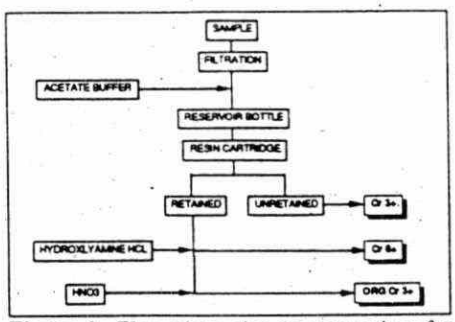


Figure 1 *Flow chart showing procedure for the separation of the redox species of chromium. Detailed explanation is provided in the text.*

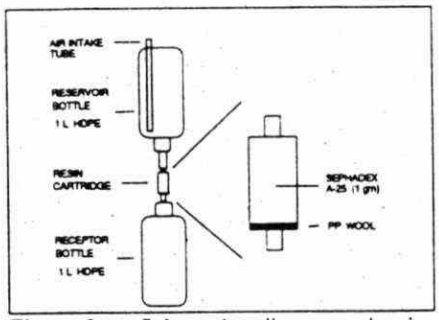


Figure 2 *Schematic diagram showing arrangement of hanging bottle method. A sample of 500 ml is placed in the reservoir bottle and allowed to pass through the resin cartridge into the receptor bottle.*

BP22

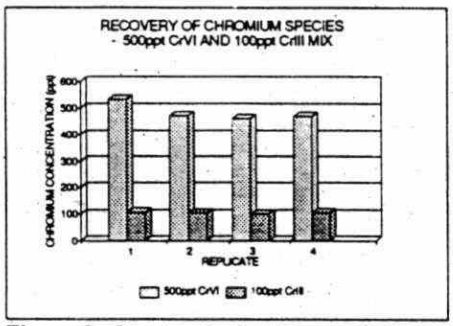


Figure 3 *Bar graph showing recoveries for 500ppt Cr(VI) - 100ppt Cr(III) mix. All replicates are subsamples of the same mixture, each being passed through different cartridges.*

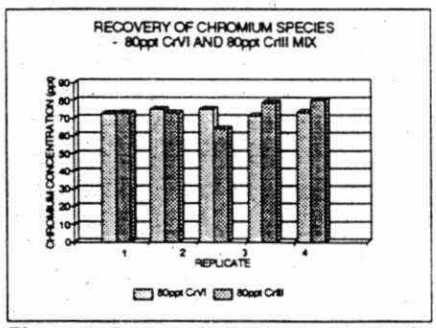


Figure 4 *Bar graph showing recoveries for 80ppt Cr(VI) - 80ppt Cr(III) mix. All replicates are subsamples of the same mixture, each being passed through different cartridges.*

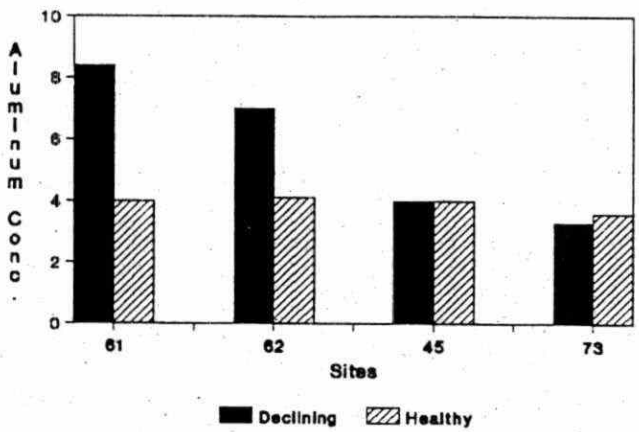


Figure 1. Aluminum concentrations (ppm) in the wood xylem of healthy (H) and declining (D) trees from the study sites.

BP23

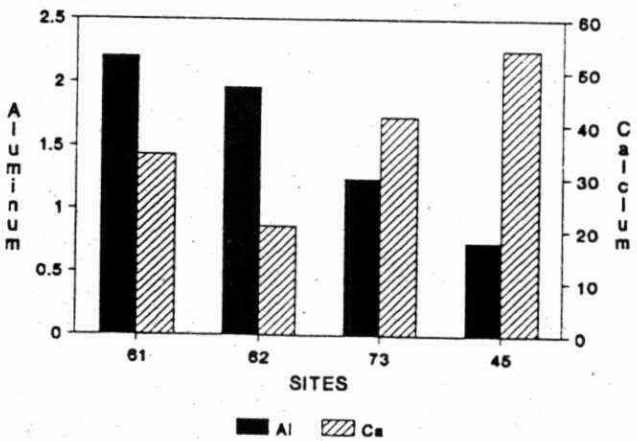


Figure 2. Extractable aluminum and calcium concentrations (ppm) in the soils of the study sites.

Figure 1. Oxidation of p-Cresol with Fenton's Reagent

AP26

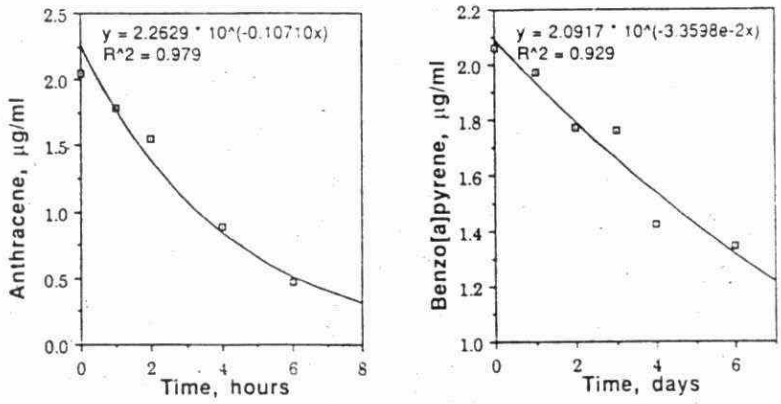


Fig. 1. Photooxidation of Anthracene and Benzo(a)pyrene in SSR. Concentration of intact chemical remaining is plotted as a function of time.

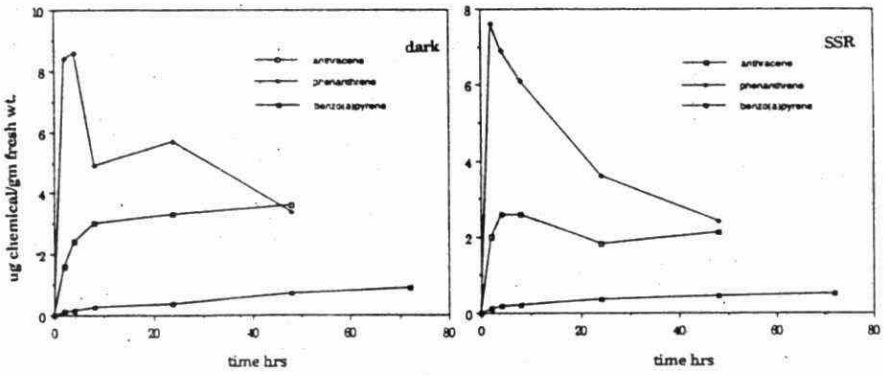


Fig. 2. Assimilation of ^{14}C-PAHs by *Lemna* in darkness and SSR. Data is presented as amount of the chemical per fresh weight of the plants. Chemical content is based on amount of intact PAH at the start of the experiment.

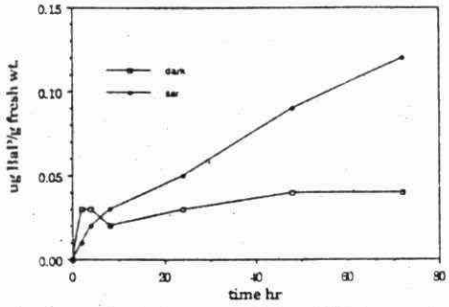
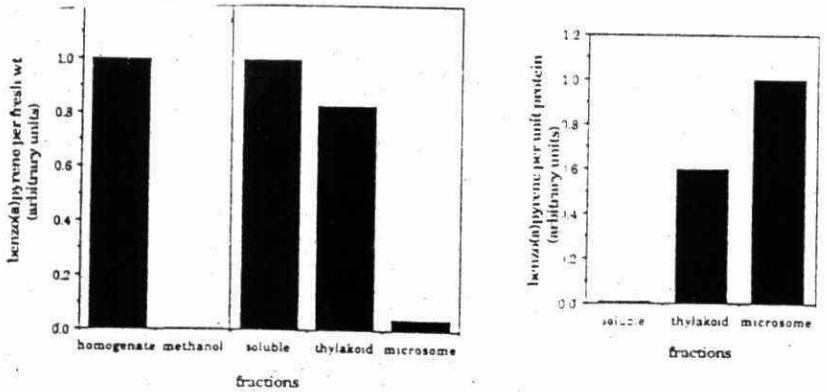


Fig. 3. Assimilation by *Lemna* in darkness and SSR of ^{14}C-Benzo(a)pyrene adsorbed onto sand. Benzo(a)pyrene was adsorbed onto sand (Sigma), placed in *Lemna* growth medium and incubated with *Lemna*. Data is presented as in Fig. 2.



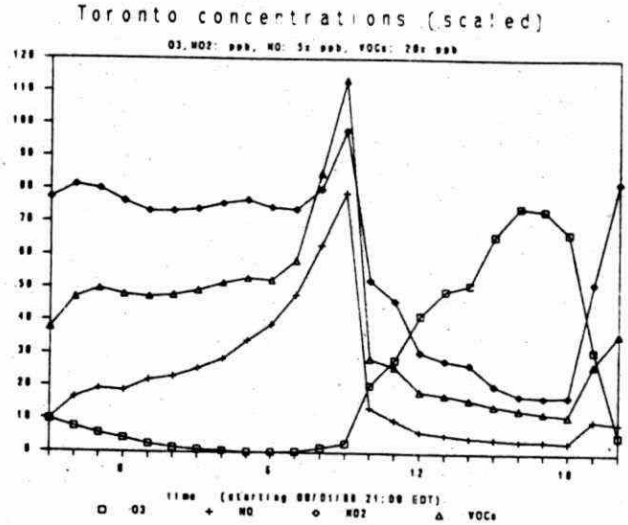


Figure 1

AP27

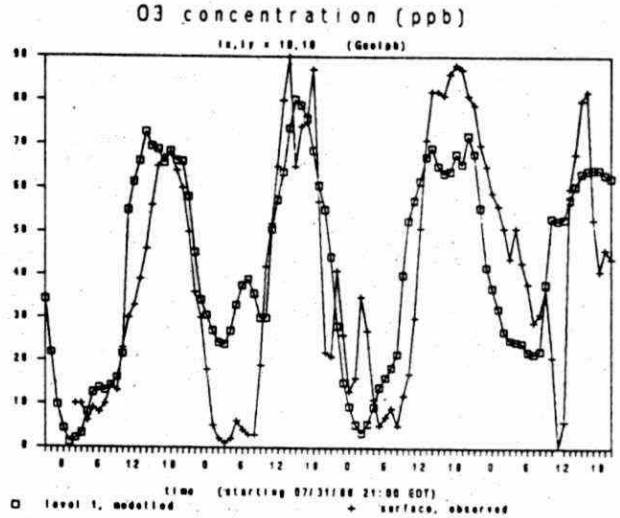


Figure 2

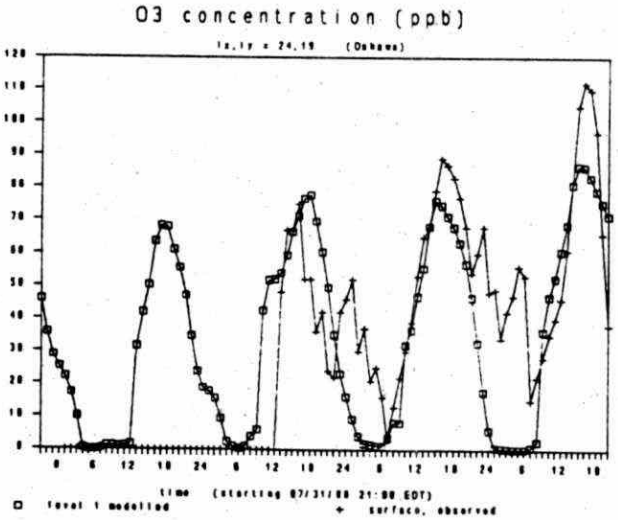


Figure 3

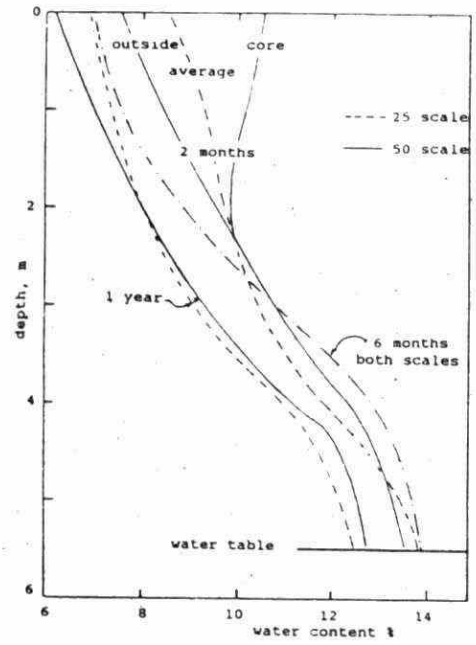


Figure 1 Water content profiles at various stages of infiltration

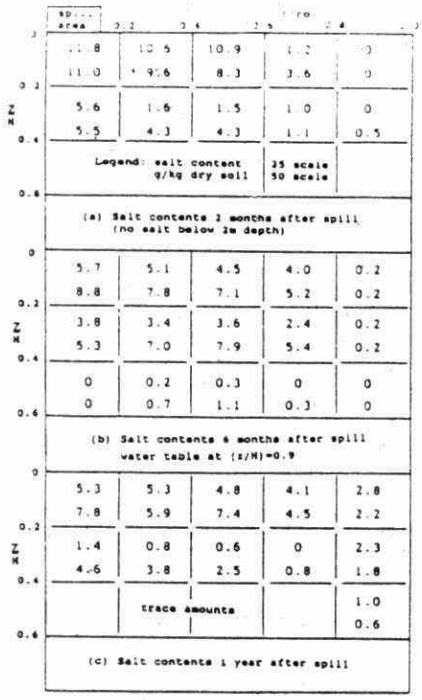
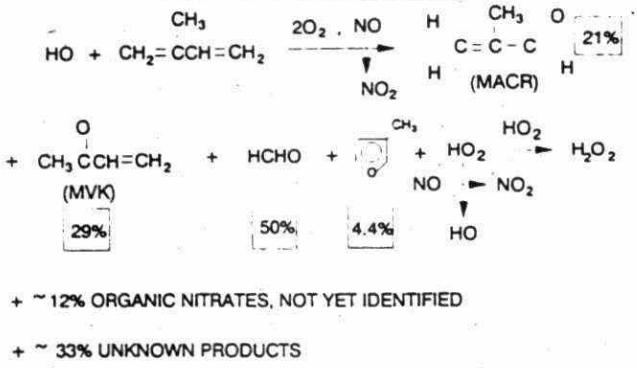


Figure 2 Measured salt contents

BP36

ISOPRENE OXIDATION



+ ~12% ORGANIC NITRATES, NOT YET IDENTIFIED

+ ~ 33% UNKNOWN PRODUCTS

Figure 3

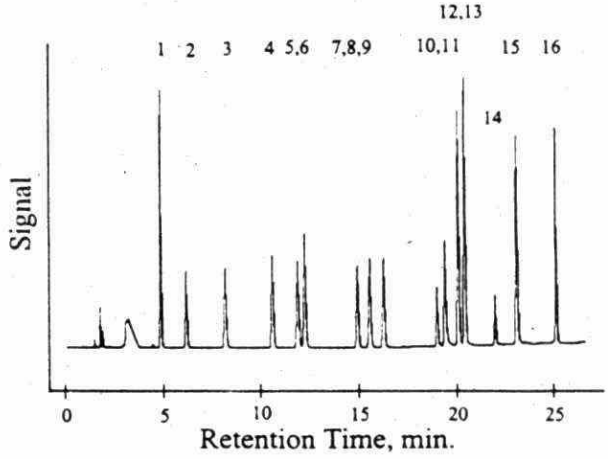
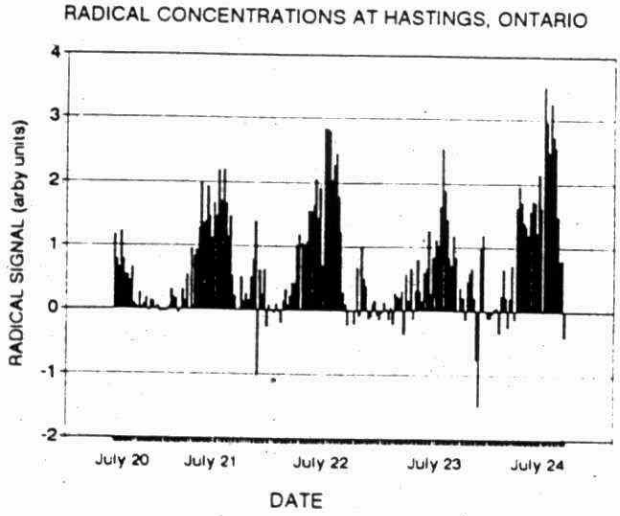


Figure 2

AP37



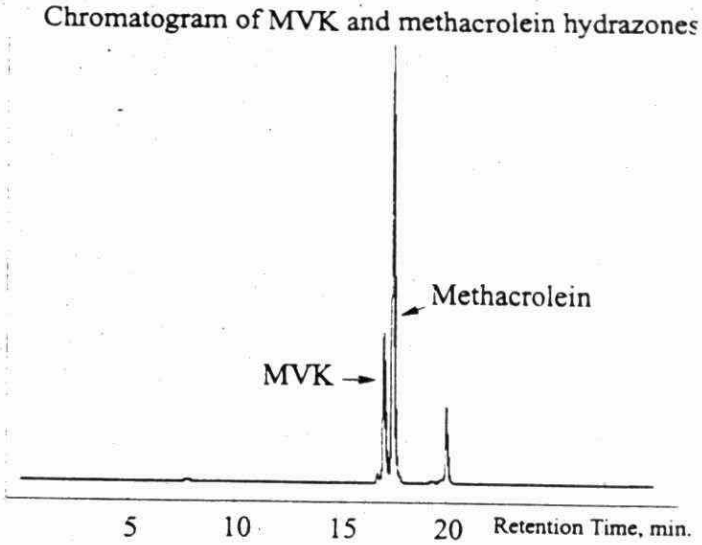


Figure 1 Simulated Unsaturated and Saturated Zone

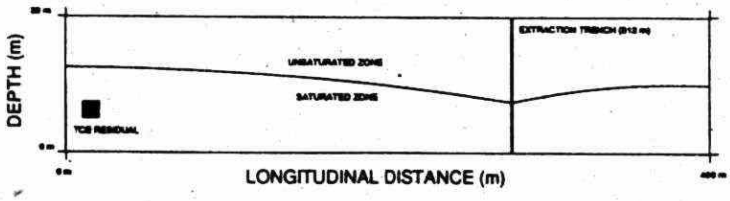


Figure 2 LOG(10) Water Concentrations (mg/L) for Case 1

BP37

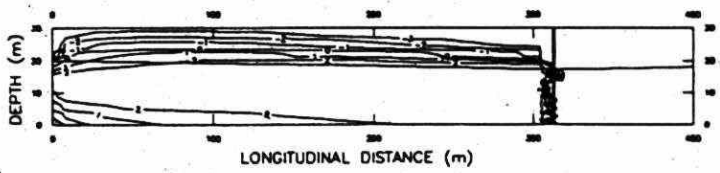


Figure 3 LOG(10) Water Concentrations (mg/L) for Case 2

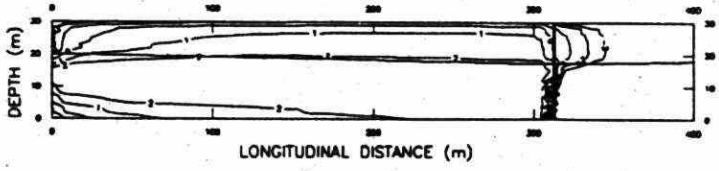
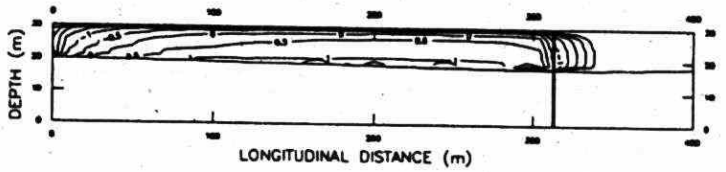


Figure 4 LOG(10) Gas Concentrations (mg/L) for Case 2



BP38

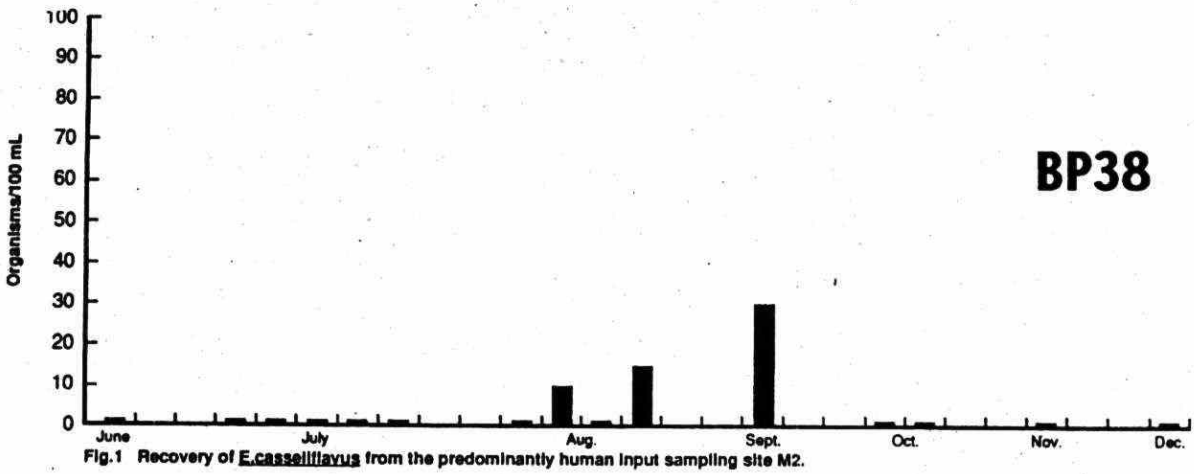


Fig.1 Recovery of E.casseliflavus from the predominantly human input sampling site M2.

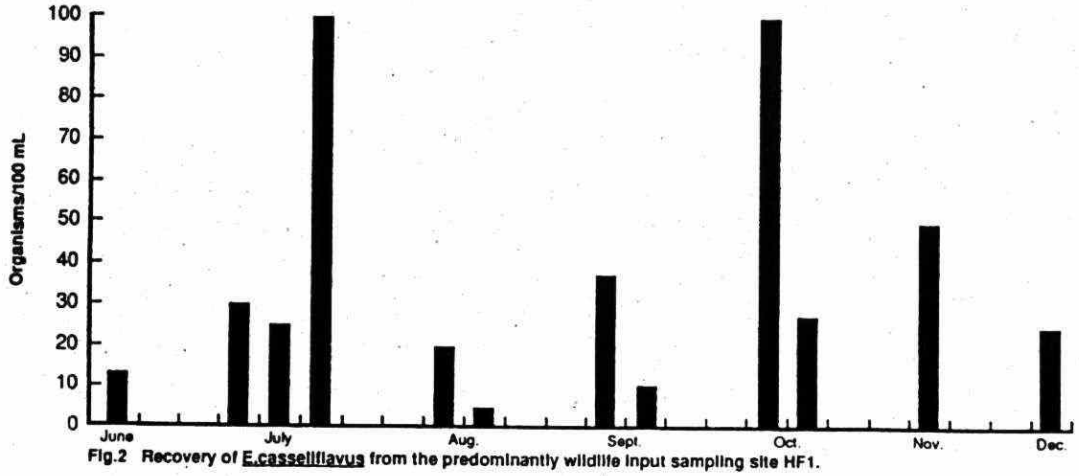
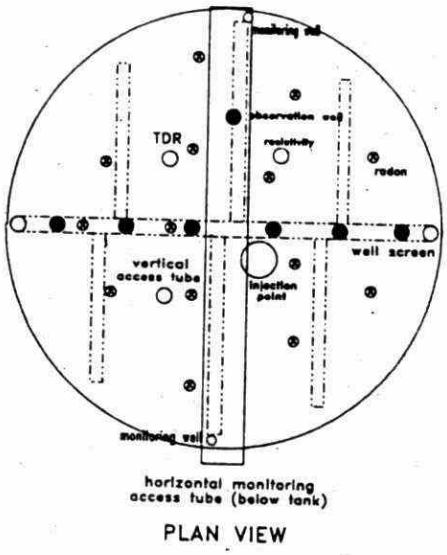
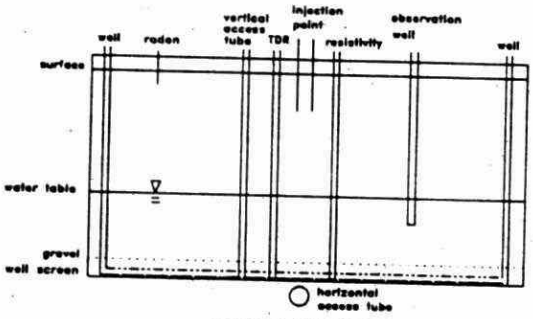


Fig.2 Recovery of E.casseliflavus from the predominantly wildlife input sampling site HF1.

FIG. 1: Test cell with monitoring devices and observation wells shown. The wells are not screened but connect to a network of screened pipe within the gravel layer at the bottom of the tank. The monitoring wells are screened over their bottom 15 cm. The horizontal access tube is used for GPR transillumination experiments.



PLAN VIEW



CROSS SECTION

AP38

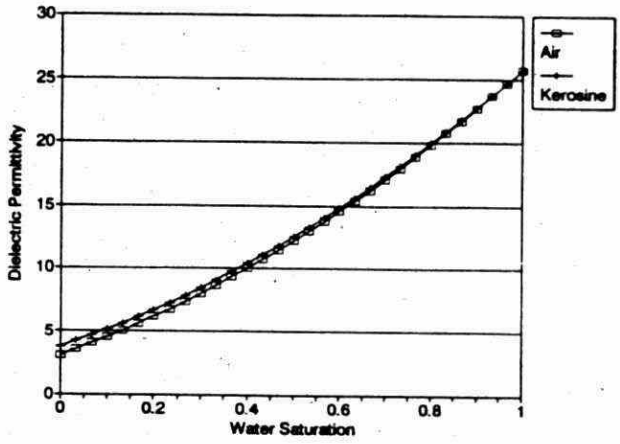


FIG. 2: Predicted relative dielectric permittivity of a soil at 500 MHz in which the pore space (40% porosity) is filled with a mixture of water and another fluid (kerosine or water). Note that the response is almost identical for kerosine and air, except at low water saturation.

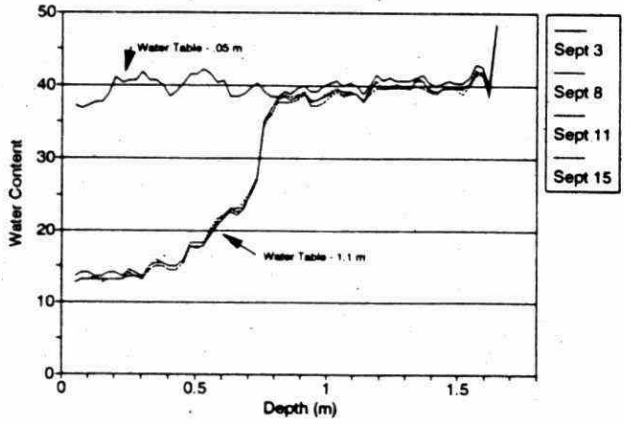


FIG. 3: Water content computed from measured dielectric permittivity on in situ TDR probe. Each profile consists of 64 measurement points. The water table was lowered to 1.1 m just after the set of measurements taken on September 3. The high value at the bottom is within the gravel pack at the bottom of the tank.

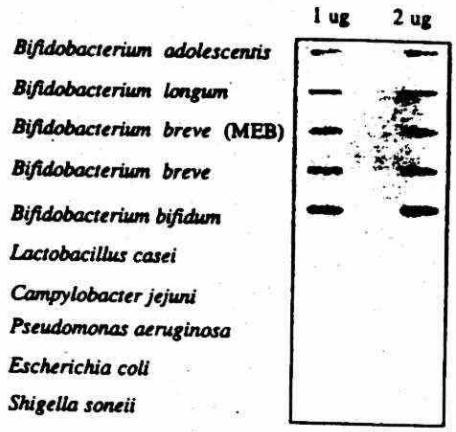


Figure 1.

Slot-blot hybridization of genomic DNA of various bifidobacteria and non-bifidobacteria to DNA probe pA34.

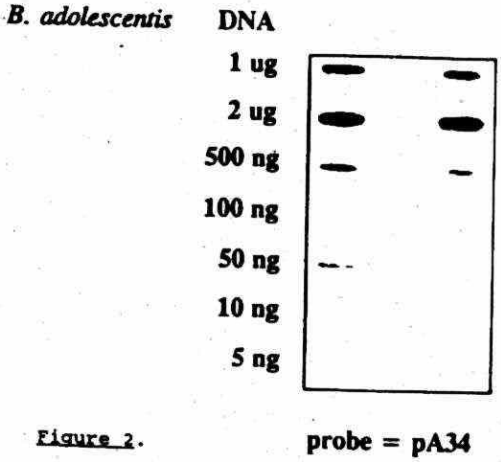
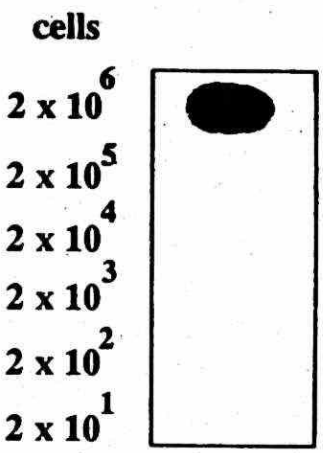


Figure 2.

Determination of sensitivity of DNA probe pA34. Decreasing amounts of *B. adolescentis* DNA slot-blotted onto nylon membrane were hybridized to radioactively-labelled pA34.

Figure 3. Determination of sensitivity of DNA probe pA34. Decreasing numbers of *B. adolescentis* cells were lysed and slot-blotted onto nylon membrane followed by hybridization to radioactively-labelled pA34.

BP39




```
                                                                30
GTC ATC GAA GGC GCT GTC AAG GAC CTC ACT CTG ATC ACC GGC CAG AAG CCG AAG ATC ACC  60
Leu Ile Glu Gly Ala Val Lys Asp Leu Thr Leu Ile Thr Gly Gln Lys Pro Lys Ile Thr

                                                                90
AAG GCT AAG AAG TCT GTC GCG CAG TTC CAC CTG CGT GAG GGC CAG GCC ATC GGC GCC TAC 120
Lys Ala Lys Lys Ser Val Ala Gln Phe His Leu Arg Glu Gly Gln Ala Ile Gly Ala Tyr

                                                               150
GTC ACC CTG CGT GGC GAG CGC ATG TGG GAG TTC CTG GAT CGC CTT CTG ACC ATG GCT CTG 180
Val Thr Leu Arg Gly Glu Arg Met Trp Glu Phe Leu Asp Arg Leu Leu Thr Met Ala Leu

                                                               210
CCG CGT ATC CGC GAT TTC CGC GGC ATC AAC GGC GAC CAG TTC GAT GGT CAG GGC AAC TAC 240
Pro Arg Ile Arg Asp Phe Arg Gly Ile Asn Gly Asp Gln Phe Asp Gly Gln Gly Asn Tyr

                                                               270
AAC TTT GGC CTC ACC GAG CAG TCC ATG TTC CAC GAG ATC GAT CCG GAT TCG ATC GAT CAC 300
Asn Phe Gly Leu Thr Glu Gln Ser Met Phe His Glu Ile Asp Pro Asp Ser Ile Asp His

                                                               330
CAG CGT GGT ATG GAC ATC ACC GTG GTG ACC AGC ACC AAG GAC GAC AAG GAA G
Gln Arg Gly Met Asp Ile Thr Val Val Thr Ser Thr Lys Asp Asp Lys Glu
```

Figure 4. DNA and translated protein sequence of pA34.

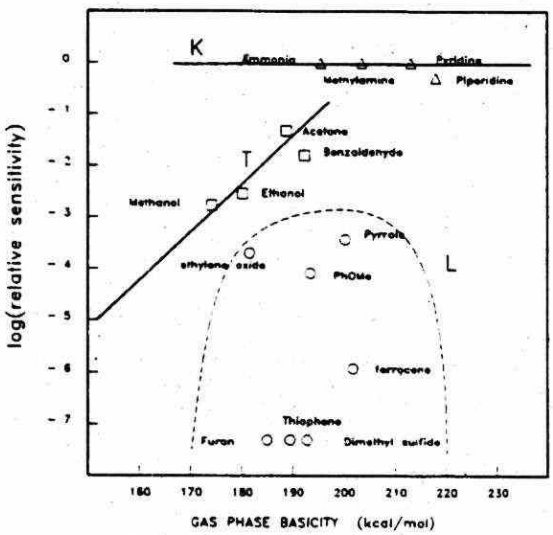


Figure 1 The relative sensitivities of some compounds in the three classes according to Kebarle *et al.*: see text.

AP40

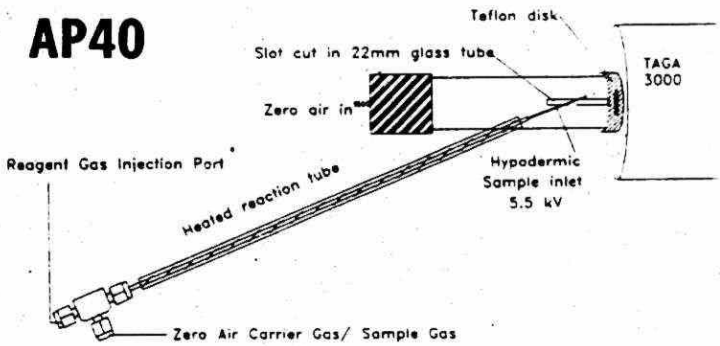


Figure 2 The Low-Volume Reactor Source.

BP41

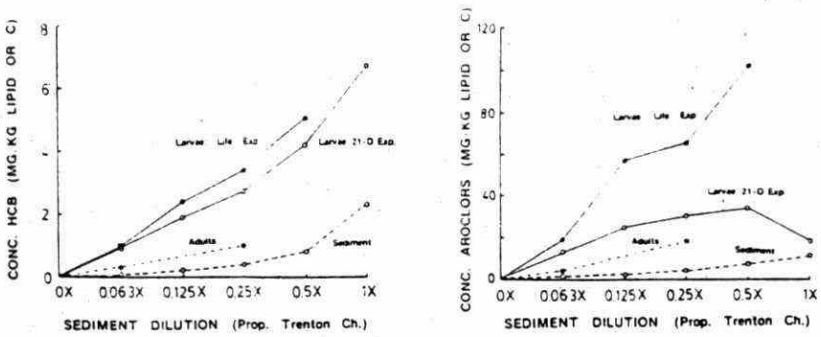
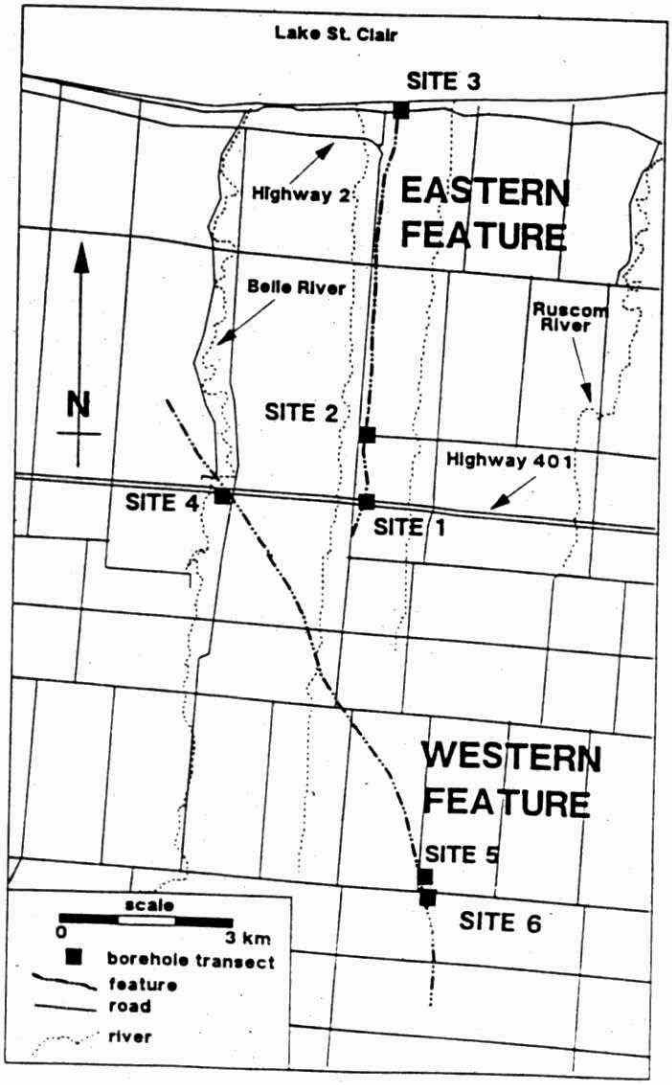
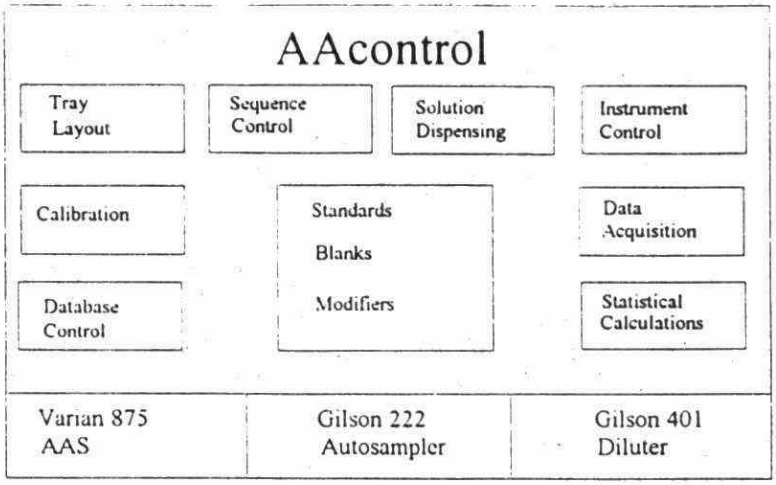


Figure 1. Mean (±1 SE) concentration of HCB (A) and total PCBs (B) in sediment and Hexagenia limbata larvae and adults after 21 and 244 d in sediment mixtures ranging from pure (1X) Trenton Channel sediment to pure (0X) STND3 sediment. Standard error bars are less than the diameter of the points. Open points and dashed line, sediment after 244 d; solid points and dotted-and-dashed line, adults after 244 d; open points and solid line, larvae after 21-d; solid points and solid line, larvae after 244 d.

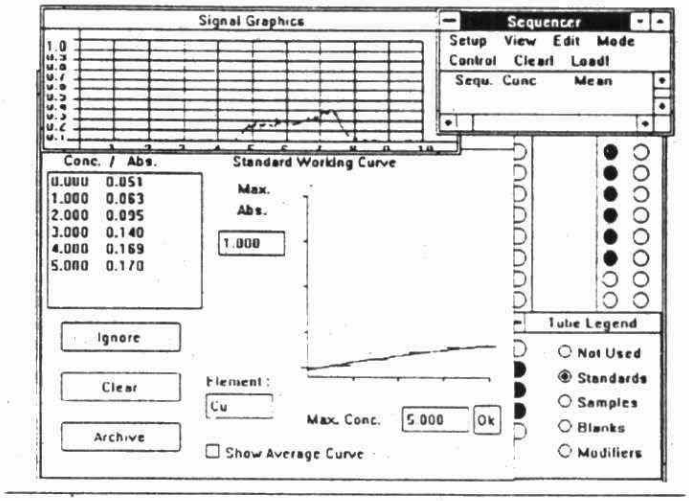
Figure 1. Location of linear morphological features

BP42





BP44



BP44A

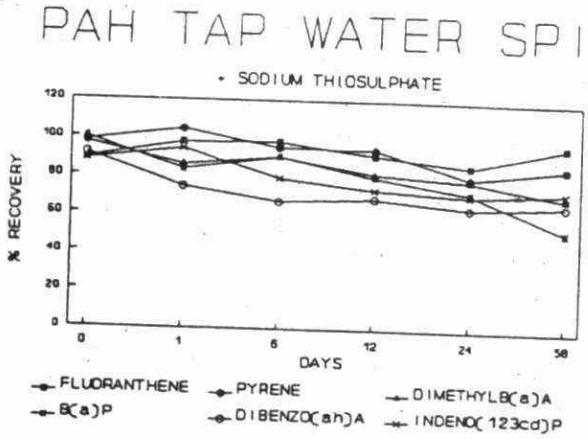
Figure 2. The user interface in AAcontrol

Table 2. Knowledge Domain Matrix

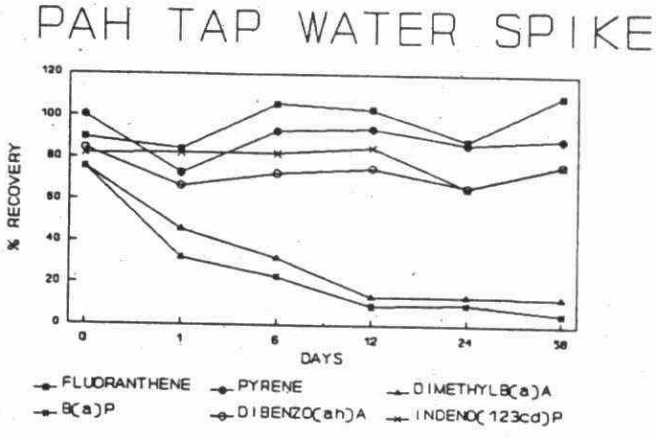
	1. Heavier than air, flammable vapour	2. Solid floats on water	3. Heavier than air, nonflammable vapour	4. Lighter than air, nonflammable vapour	5. Vapour which heavier than air when spilled, then become lighter	6. Water soluble vapour	7. Floating non-spreading liquids	8. Floating & highly flammable liquids	9. Floating & Low flammable liquids	10. Floating & Spreading liquids	11. Other O containing floating liquids	12. Floating liquid Esters	13. Floating liquid simple hydrocarbons	14. Sinking solid chemicals	15. Sinking inorganic liquids	16. Sinking halogenated liquid organics	17. Sinking aromatic liquid organics	18. Water soluble inorganic acids	19. Water soluble inorganic bases	20. Water soluble ionic inorganics	21. Water soluble heavy metal containing inorganics	22. Water soluble halogens	23. Water soluble organic acids	24. Water soluble alcohols	25. Water soluble esters	26. Water soluble amines	27. Water soluble S containing organics	28 Water soluble Cl containing organics	29. Water soluble & nonbiodegradable organics with ionically bound metal	30. Water soluble & biodegradable organics
1. It is in vapour phase	T		T	T	T	T																								
2. It is nonflammable		?	T	T	?	?	?			?	?	?		?	T	?	?	T	T	T	T	T	T	?	?	?	?	?	?	?
3. Heavier than air when spilled, then become lighter					T	?																								
4. It dissolves in water						T												T	T	T	T	T	T	T	T	T	T	T	T	T
5. It is in liquid phase							T	T	T	T	T	T	T		T	T	T	?	?	?	?	?	T	T	T	T	?	T		?
6. Some contain N	T		T	T	T	T		T	T	T							T	T	T	T	T						T			T
7. It has low flammability	?	?	?	?	?	?	?		T	?	?	?	?	?	?	?	?							?	?	?	?	?	?	?
8. It spread into water phase	?		?	?	?	T		?	?	T								T	T	T	T	T	T	T	T	T	T	T	T	T
9. Some contain O	T	T	T		T	T	T	T	T	T	T	T		T		T	T	T	T	T	T		T	T	T	T	T	T	T	T
10. Ester	?		?			?		?	?	?		?													T					?
11. Some are simple hydrocarbon	T	T	T		T		T	T	T				T																	
12. Sinks in water														T	T	T	T													
13. Salt			?			?								?						T	T						?		T	?
14. Biodegradable	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?		T
15. Contain heavy metal														?	?						T									
16. Organic compound	?	T	?		T	?	T	T	T	T	T	T	T	?		T	T						T	T	T	T	T	T	T	T
17. Alcohol	?	?	?		?	?		?	?	?														T						
18. Some contain S	T		T		T	T								T				T		T	T						T			T
19. Halogenated	?	?	?	?	?	?								?		T	?	?		?	?							T		

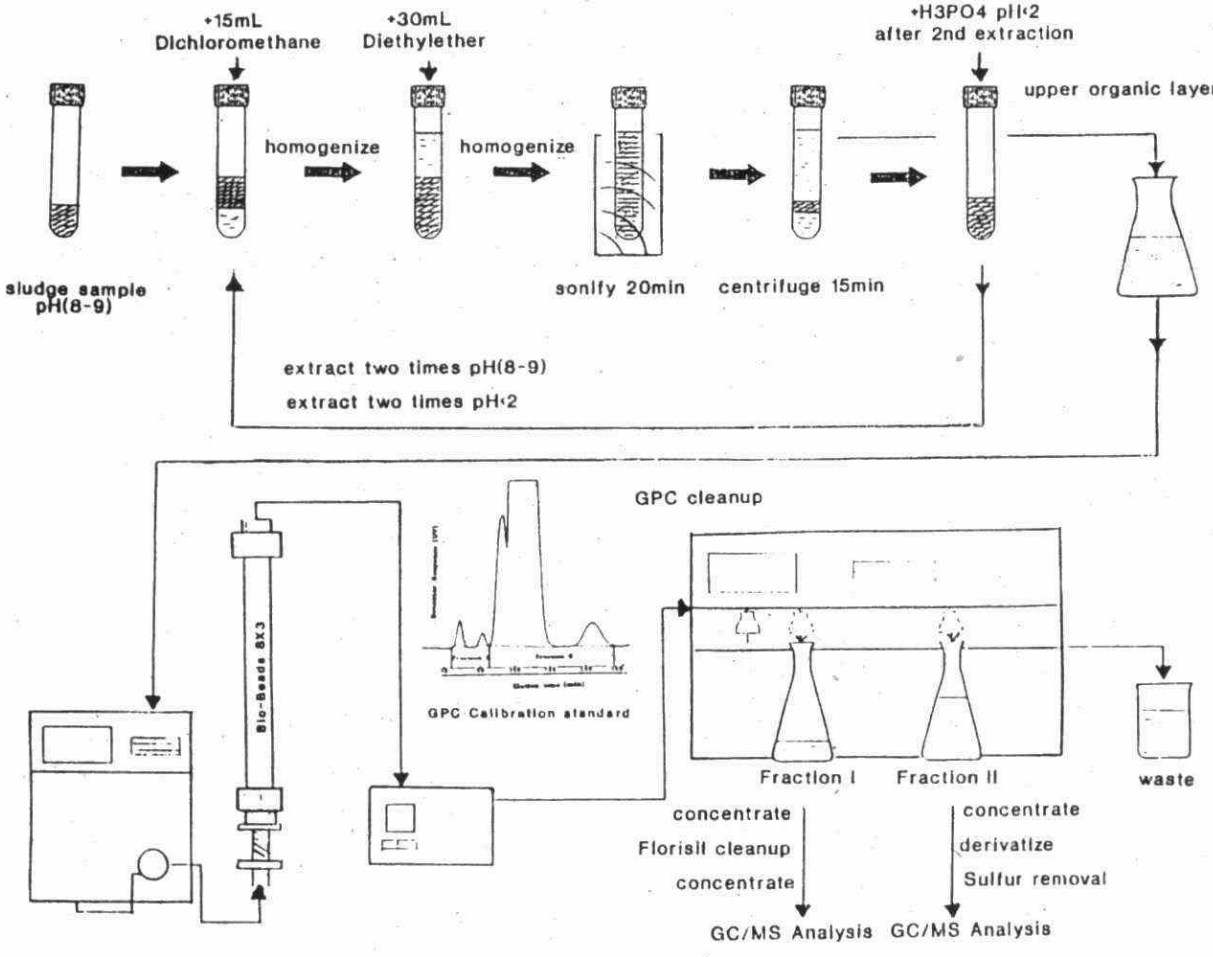
Expert system as response to emergency chemical spills. Part I: Knowledge development and System design

The Table above represent the knowledge used by SPILLexpert to categorize hazardous chemicals into different response groups.



BP48





BP49

Fig.1 Sample preparation

		1. Sensitivity loss	2. Retention time change	3. High background noise	4. Ghost peak(s)	5. Peak tailing	6. Baseline drift	7. Syringe/injection related peak signal	8. Leading peak	9. Unresolved peak(s)	10. Band broadening	11. Cannot zero baseline	12. Irregular spikes	13. Splitting peak	14. No peak(s)	15. Sudden drop-off normal peak
Injection	1. Leaking syringe	T						T								
	2. Dirt in the syringe				T			T								
	3. Large sample size		F						T		F					
	4. Double injection							T						T		
	5. Slow injection		T					T			T					
Column	6. Sample decomposition	T	F		T											
	7. Late elute peak(s)				T						T					
	8. High column temperature		F	F		F				T						
	9. Low column temperature		F						T		T					
	10. Adsorption of sample on active sites	F	T			T										
	11. Reaction of sample with GC parts	T	T		T	T										
	12. Unstable column temperature		T				T									
	13. Column bleed	F	F	T			T									
	14. Column bleed	F		T		F						T				
	15. Leaking at column exit	T		T			T					F				
	16. Leaking severe	T	T												T	
	17. Loose column fitting	T	T										T			
	18. Column degradation								T	T	T					
	19. Contaminated column			T	F	T										
*	20. Wrong fuel gas flow	T		F								T				
Detector	21. Dust burned in flame	F											T			
	22. Unstable detector temperature	T		F			T									
	23. Flame not ignited	F													T	
	24. Contaminated detector	T		T			T					T				
CarrierGas	25. Contaminated carrier gas			T	T	F										
	26. Low carrier gas flow		T						T	F						
	27. High carrier gas flow		T						F	T						
	28. High carrier gas flow			T						T						T
Injector	29. Dirt in the injector			T										T		
	30. Dirt in the injector			T	T	T										
	31. Low injector temperature					T				T	T					
	32. Leaking at septum	T	T		T	F										
* FuelGas																

Figure 1. Knowledge domain matrix in GC diagnostic system

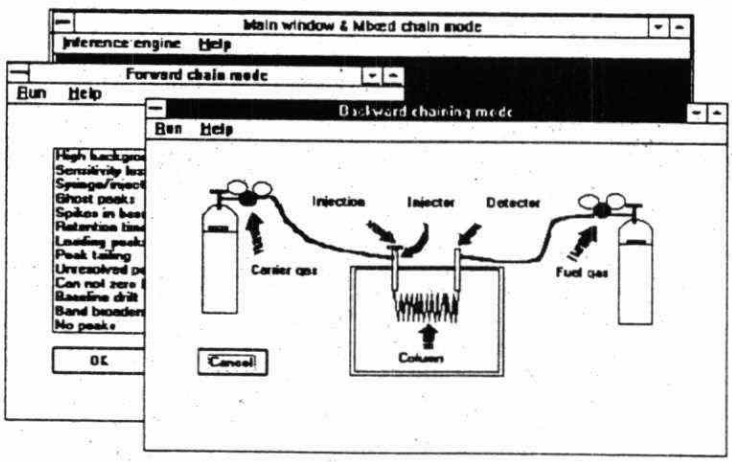


Figure 2. Window design of an icon-based GC diagnostic system

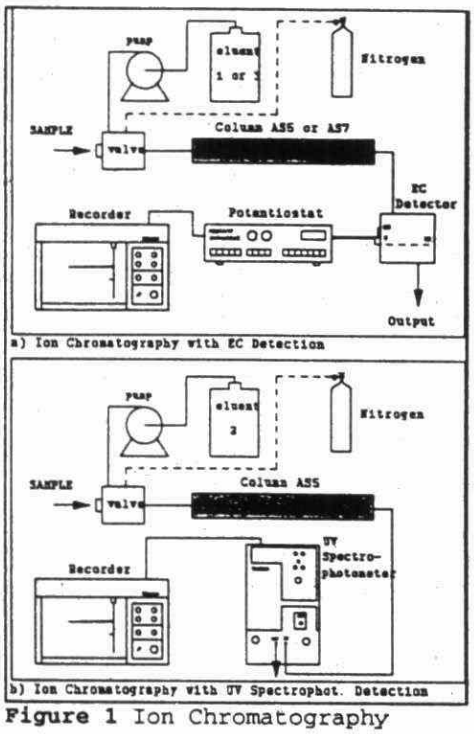


Figure 1 Ion Chromatography

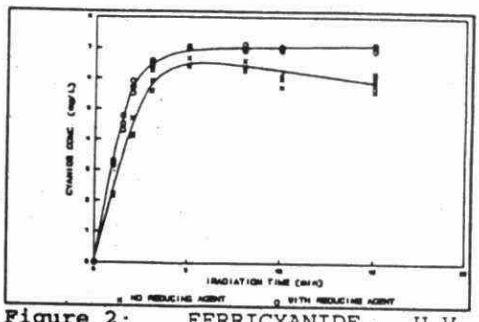


Figure 2: FERRICYANIDE U.V. IRRADIATION

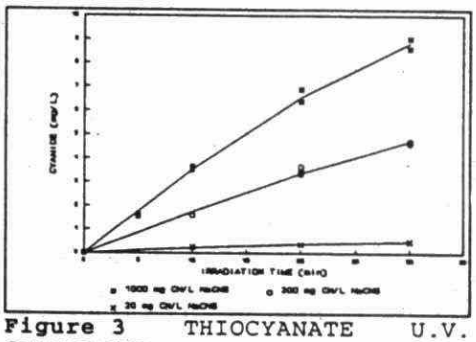


Figure 3 THIOCYANATE U.V. IRRADIATED.

AP45

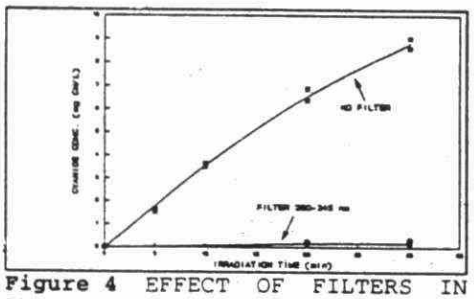


Figure 4 EFFECT OF FILTERS IN THIOCYANATE U.V. IRRADIATION.

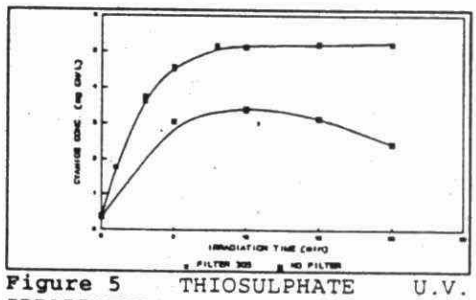


Figure 5 THIOSULPHATE U.V. IRRADIATION.

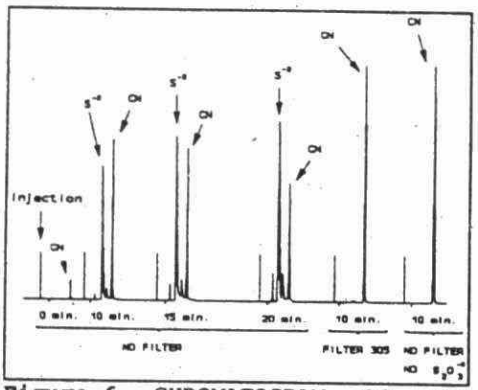


Figure 6 CHROMATOGRAM OF THE THIOSULPHATE U.V. IRRADIATED.

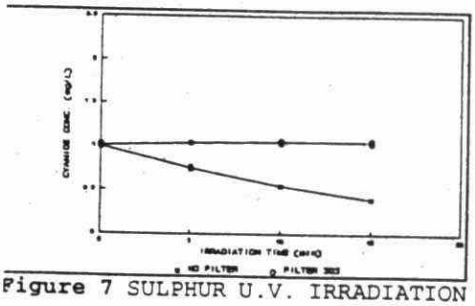


Figure 7 SULPHUR U.V. IRRADIATION

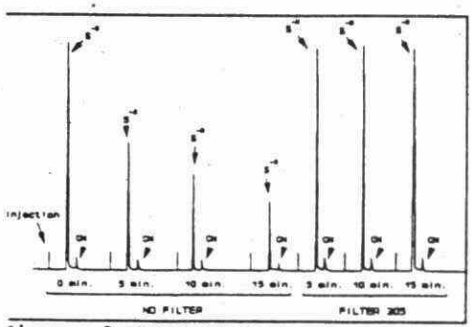


Figure 8 CHROMATOGRAM OF SULPHUR U.V. IRRADIATION.

Figure 1 : SPE System Comprised of 6-Port Valve, Cryofocussing and Dual Analytical Columns

AP46

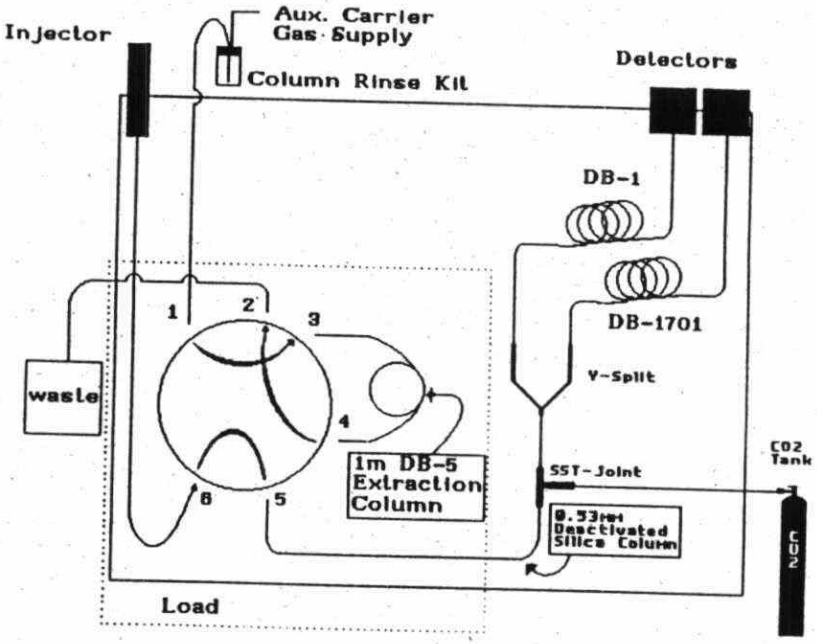
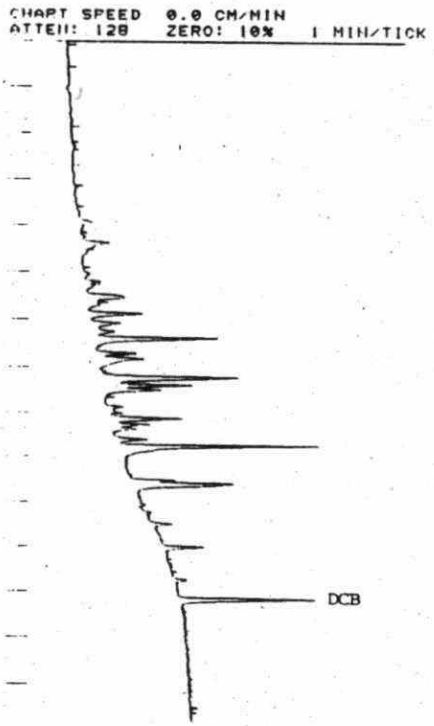
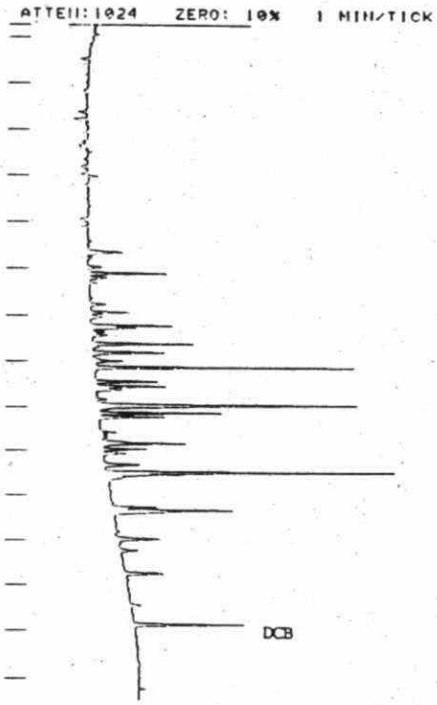


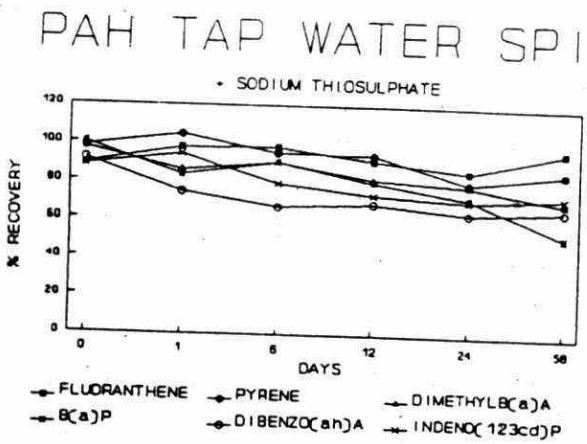
Figure 2 : Comparison of PCB Peak Shapes for a Chromatogram Produced using Splitter and one using Cryofocussing



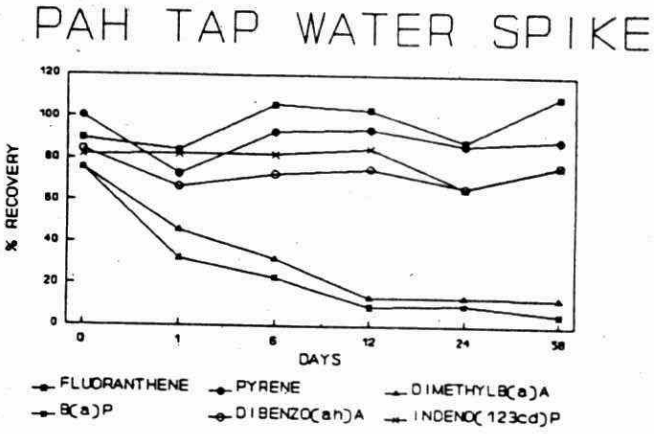
SPE/Thermal Desorption using Splitter, DB-1701 analytical column 500 ng/L PCBs

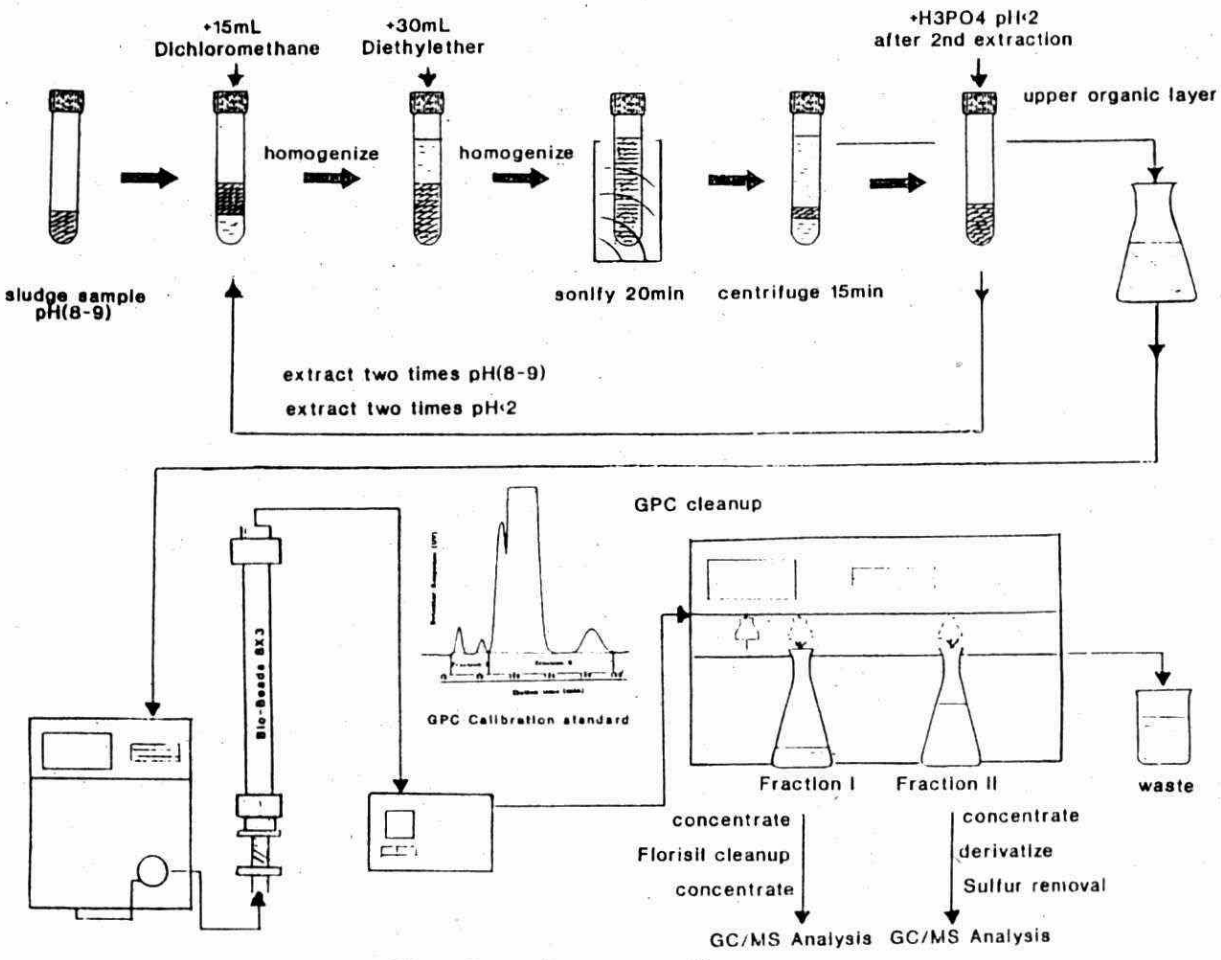


SPE/Thermal Desorption using Cryofocussing, DB-1701 analytical column 133 ng/L PCBs



BP48





BP49

Fig.1 Sample preparation

AP48

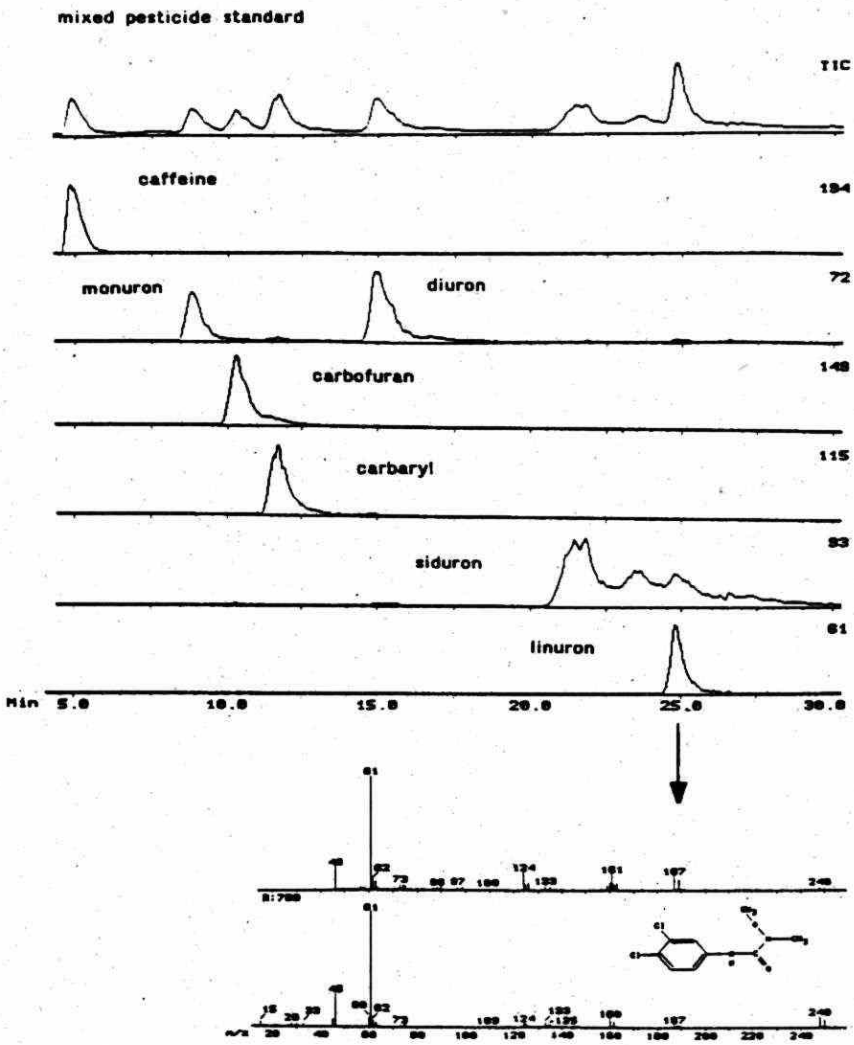
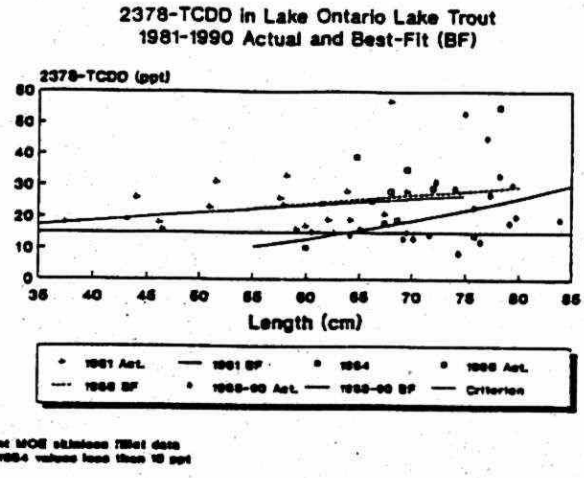
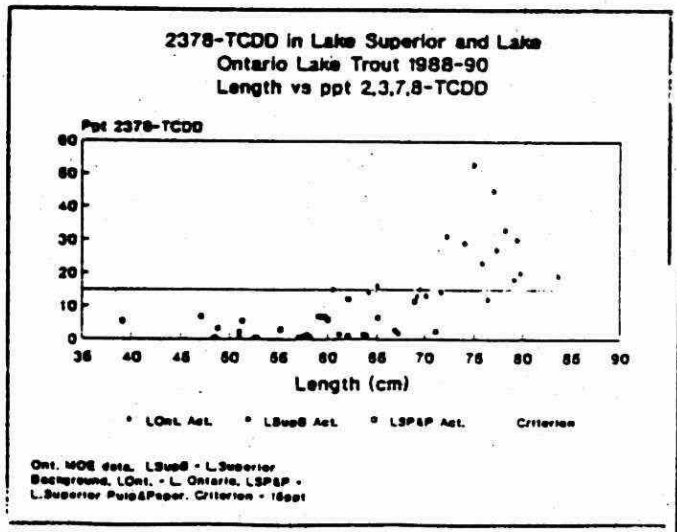


Figure 1. Total ion and mass chromatograms for a mixed pesticide standard. Each peak represents approximately 2000 ng of analyte injected into the mass spectrometer via a 2.1 mm id x 25 cm, C_{18}, 5μm LC column and the particle beam interface. The flow rate was 0.2 mL/min with an acetonitrile/water gradient starting at 30% acetonitrile and reaching 100% acetonitrile at 30 minutes. Spectra obtained for linuron (top) and its library match (bottom) are also shown.

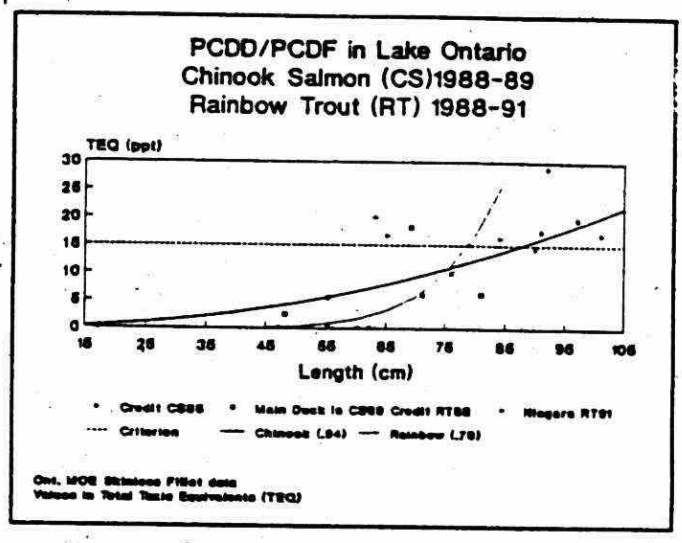
AP50

Figure 1





AP50



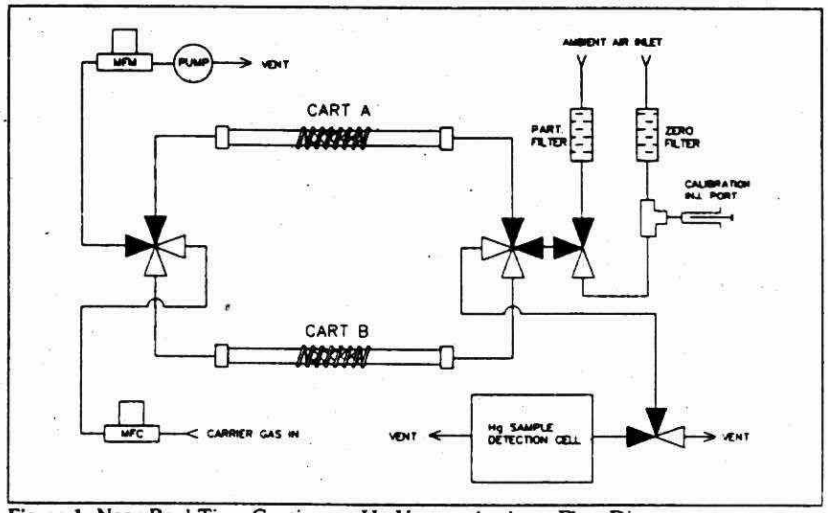


Figure 1: Near Real Time Continuous Hg Vapour Analyzer Flow Diagram.

BP50

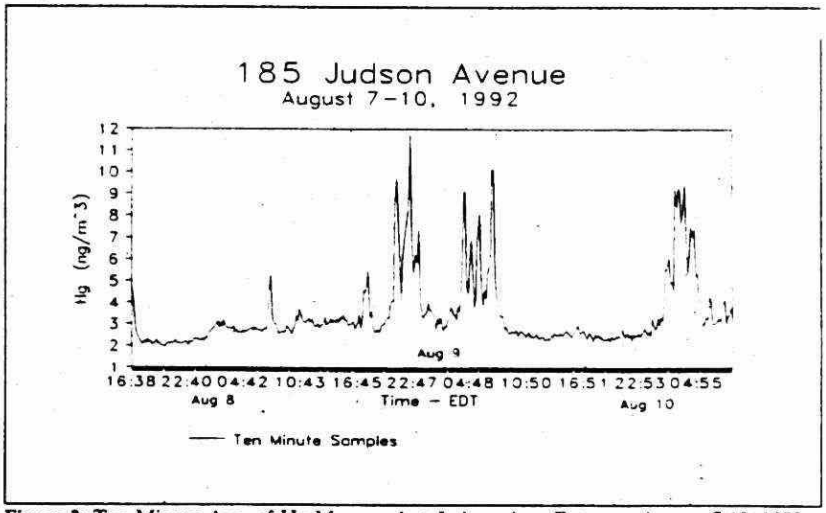
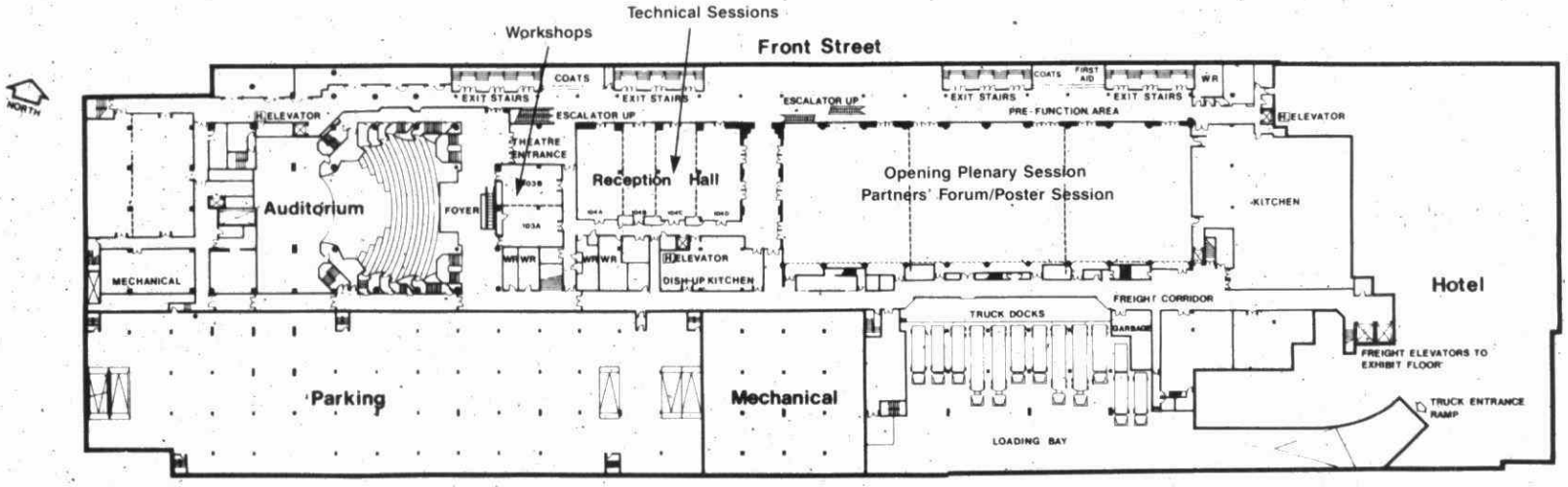


Figure 2: Ten-Minute Avg. of Hg Measured at Judson Ave. Between August 7-10, 1992.

Metro Toronto Convention Centre



LOWER LEVEL

ENVIRONMENTAL

RESEARCH & TECHNOLOGY

Partnerships for a

Cleaner Environment

The Environmental Technologies Program

Ontario
Environment
Environnement

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THE ENVIRONMENTAL TECHNOLOGIES PROGRAM

One of the most important tasks in this decade is finding new ways to protect and improve our environment. It's a task that will take time, imagination, painstaking work, cooperation - and money.

The Environmental Technologies Program (ETP) of the Ontario Ministry of the Environment provides financial assistance to help develop new technologies to overcome environmentally damaging practices. The program's focus is on the latter stages of the technology innovation process; the development, refinement and commercialization of the product or process.

Developmental projects under the ETP fall into seven categories:

- waste management
- water and sewage treatment
- 3Rs technologies
- analytical instrumentation
- tire technologies
- air pollution control
- socio-economic analysis

To be eligible for funding, recipients must operate or reside in Ontario. A wide range of organizations qualify, including; Canadian corporations, subsidiaries of foreign-owned firms, universities and municipalities.

Typical ventures eligible for funding include:

- research leading to the development of an innovative process or product
- equipment prototype development and testing
- pilot-scale equipment refinement and adaptation
- field trials and demonstration of innovative technologies to determine system performance, reliability and cost effectiveness
- initial demonstration of foreign technologies to determine their suitability to Ontario conditions

Only developmental or demonstration aspects of the technology are eligible for support. Costs associated with full-scale production and marketing are not supported. Generally, funding for a project does not exceed 50 per cent of the total cost to a maximum of $500,000 annually for up to three years.

Applications for ETP funding are considered twice a year. Submissions must include detailed technical and commercial objectives, a budget, anticipated goals and a commercialization plan. The contribution of the project to the ministry's technology and regulatory needs must be clearly defined, as must the potential value to the environment.

The review of each proposal and any subsequent recommendations for funding are based on broad selection criteria, including:

- net contribution to environmental protection
- effectiveness in addressing ministry technical, policy and regulatory requirements
- scientific and technical excellence
- degree of innovation
- commercialization potential locally and internationally
- industrial and economic benefits
- financial and management capability of the applicant

Preference is given to technologies that prevent or reduce pollution at the source, rather than at the end of the pipe or stack. Those which assist organizations to meet regulatory requirements are favoured.

This booklet lists projects that were in progress, or for which contractual agreement was met for project initiation, during the 1991/92 financial year. The organization developing the technology is listed along with the project contact person and contact details. The program project number (e.g. ET 010) is also provided.

Participation in the ETP can be a winning situation for everyone - the organizations that develop the new products and processes, the government, all those who ultimately benefit from the new technologies and, most of all, our environment.

The Environmental Technologies Program is coordinated by the Research and Technology Branch. For guidelines, application forms or further information on the program, please write or call:

Research and Technology Branch
Ontario Ministry of the Environment
135 St. Clair Avenue West
Toronto, Ontario, Canada
M4V 1P5

Telephone: (416) 323-4657
Fax: (416) 323-4437

WASTE MANAGEMENT

Demonstration of Vitrokele™ Technology to Recycle Cyanides and Metals at Gold Plants

Jasmetech Metal Technologies Inc.
Dr. Denis Kidby

(519) 836-9494

67 Watson Rd. S.
Guelph, Ont.
N1H 6H8

ET 010

In this project, an economically attractive process based on Vitrokele™ technology for producing environmentally acceptable effluent from gold mills was demonstrated at Bell Creek Mine near Timmins, Ont. Vitrokele™, a family of synthetic adsorbents, capture cyanide as well as significant quantities of such heavy metals as copper from slurries and discharge solutions. The cyanide is recycled back to the primary gold leaching circuit and the metals recovered for other uses. Potentially, this technology could result in a pollution abatement process which recovers all capital expenditure and produces an ongoing operating profit.

Plasma Gasification Feasibility Study of Hospital Solid Waste PSW89-01

Resorption Canada Ltd.
Mr. George Carter

(613) 822-1842

2610 Del Zotto Ave.
R.R. #5
Gloucester, Ont.
K1G 3N3

ET 032

An investigation of the plasma gasification disposal of Hospital Solid Waste in their plasma research facility is the focus of this company's developmental work. The process operates at approximately 1200°C and produces an inert slag which may have commercial uses and a medium heating value gas which may be burned immediately or stored for later use. The plasma disposal system requires an extremely small space compared to other disposal technologies. Optimal operating parameters for the process will be determined and a full environmental analysis for organics, acid gases and trace metals in the product gas, flue gas and quencher water will be conducted, plus a full leachate analysis of the slag.

Electrolytic Recovery of Zinc from Galvanized Steel

Metal Recovery Industries Inc.
Mr. Andrew Kellner

(416) 549-9894

670 Strathearne Ave. N.
Hamilton, Ont.
L8H 7N7

ET 033

An alkaline zinc electrowinning process which can be used in conjunction with an electrochemical degalvanizing process to produce a high quality zinc product is under development in this project. Once operating parameters are optimized, a prototype zinc harvesting and purification system will be designed and constructed. This will allow test marketing of the recovered zinc. Successful development would afford the opportunity to recover much of the 700,000 kg of zinc waste now generated annually in galvanized steel remelting in Canada.

WASTE MANAGEMENT

Development of Innovative Electrochemical Membrane Technology to Permit Source Recovery and Recycling of Waste Acids and Etchants

Prosep Technologies Inc.
Mr. Michael Sheedy

(416) 831-2474

Unit 7, 817 Brock Rd. S.
Pickering, Ont.
L1W 3L9

ET 057

The objective of this project is the development of an electrochemical membrane process to recover and recycle waste acids, metal salts and etchants from the metal finishing industry. This will help to eliminate the production of hazardous metal hydroxide sludges and salts now produced during the conventional neutralization of such wastes. With the completion of laboratory work, a pilot plant has been constructed and is now operating. This will be followed by a full-scale demonstration at a secondary steel producer.

Treatment of Fluids Containing Organic Contaminants

Trojan Technologies Inc.
Dr. William Cairns

(519) 685-6660

845 Consortium Ct.
London, Ont.
N6E 2S8

ET 076

Under consideration in this project is the development of a process and hardware for the treatment of gases and liquids containing organic contaminants. The process could be used in the treatment of off gases, industrial effluents, groundwater recharge, potable water and wastewater. The process and equipment under development build upon Trojan Technologies' experience in UV reactor design for control of microbial contaminants in water and wastewater. The new process and hardware are being engineered to provide high level destruction of chemical contaminants present in the influent fluids.

Development of a Micro-computer Based Expert System for Mine/Mill Effluent Treatment Plant Design (Gold Industry Case)

Wastewater Technology Centre
Mr. Abbas Zaidi

(416) 336-4618

867 Lakeshore Rd.
P.O. Box 5050
Burlington, Ont.
L7R 4A6

ET 127

A micro-computer based system which can be used to design and tailor the most cost effective effluent treatment system for cyanide/metals/toxicity removal for any given gold mill is being formulated. It will be able to generate a comprehensive report containing all relevant information on process design and cost of the selected system. The expert system will be designed specifically for the Ontario gold mining industry, with capabilities for expansion into other industrial sectors and the rest of Canada.

WASTE MANAGEMENT

Extension and Finalization of the LANDIS Expert System

Dearborn Chemical Company Ltd.
Mr. David Young

(416) 279-2222

3451 Erindale Station Rd.
P.O. Box 3060, Station A
Mississauga, Ont.
L5T 3T5 ET 130

This study involves the extension and final development of the LANDIS (LANd DISposal) expert system based software decision tool to a form relevant to Canadian situations and suitable for distribution. LANDIS is a solid waste landfill disposal assessment system. It is designed to guide the user through a solid waste assessment process to determine the suitability of disposing a specific waste in a specific landfill site. Expert system rules control the evaluation process and incorporate the expertise necessary to render final conclusions and recommendations. LANDIS is also a useful tool for conducting "what if" hypothetical scenarios.

BEI/GM Research Project to Develop a Commercial Enzymatic Process for the Polishing/Removal of Contaminants from Wastewater on an Industrial Scale

Biotech Environmental Inc.
Mr. Brian Ablett

(416) 543-3097

12616 Credit View Rd.
R.R. #2
Brampton, Ont.
L6V 1A1 ET 155

An economical and effective wastewater treatment system for the removal of dissolved phenolic compounds from water is being evaluated in this project. The system under consideration is based on the immobilization of peroxidase enzyme on the granular bone product BIOBONE™. The peroxidase enzyme acts by polymerizing phenols to insoluble polyphenols which are trapped on the bone. Two demonstration reactors (intermediate and full-scale) based on this process are being evaluated for their effectiveness in phenol removal from wastewater at the General Motors foundry in St. Catharines, Ont.

Field-Based Pilot-Scale Remediation Trials for Industrially-Contaminated Environmentally-Hazardous Soils

Tallon Metal Technologies Inc.
Dr. Bruce Holbein

(519) 766-9160

67 Watson Rd. S.
Guelph, Ont.
N1H 6H8 ET 173

The focus of this project is the design, construction and operation of a field-based pilot scale plant to evaluate a metal extraction and recovery process based on synthetic Vitrokele™ adsorbents for the remediation of contaminated soil. These adsorbents are used in conjunction with standard mineral processing unit processes (soil washing) and proprietary hydrometallurgical processes to produce decontaminated soil for reuse, while recovering metals for use in other applications.

Biofiltration of Toxic Metals from Acid Mine Drainage Through Actinorhizal Plant Systems

LAC Minerals Ltd.
Mr. Jamie Quesnel

(705) 567-4911

6 Al Wende Ave.
P.O. Box 670
Kirkland Lake, Ont.
P2N 3K2

ET 175

The effectiveness of alders (Alnus rugosa) inoculated with the microsymbionts Frankia and mycorrhizal fungi as a biological filter for the control of acid mine drainage is being evaluated in this undertaking. The metal and water tolerant alder is proposed as an ideal species for the immobilization of toxic metal pollutants from contaminated soil. Following laboratory/greenhouse studies on metal uptake and tolerance, pilot test plots will be established at a selected site. This ecological approach could prove to be a novel strategy to revegetate sterile areas of former mine tailing ponds.

WATER AND SEWAGE TREATMENT

Modular Drinking Water Pilot Plant for the 1990's

Department of Civil Engineering
University of Waterloo
Dr. Peter Huck

(403) 492-4738

Waterloo, Ont.
N2L 3G1

ET 006

The focus of this development is the design, construction and testing of modular drinking water pilot plants for use in advanced investigations with different water types. State-of-the-art processes such as ozonation, granular activated carbon and biological treatment are included. Ultimately, a refined modular design will be developed to a state of market readiness for Canadian and offshore sales.

Development of Membrane Technology for Drinking Water Production: Treatment of Coloured Waters

Zenon Environmental Inc.
Dr. Pierre Cote

(416) 639-6320

845 Harrington Ct.
Burlington, Ont.
L7N 3P3

ET 007

The potential of nanofiltration membrane technology for the removal from water of a number of soluble organic compounds, many of which cause brown-tinted water is being evaluated. Apart from aesthetic problems, these organic substances react with chlorine during conventional disinfection processes to form such harmful products as trihalomethanes. Membrane technology would be an effective alternative to conventional treatments that are not completely effective and are either expensive, lead to undesirable by-products, or require spacious installations.

Demonstration of Expert System Software for Pollution Control Planning

Wastewater Technology Centre
Ms. Judy Czajkowski
(416) 336-4599

867 Lakeshore Rd.
P.O. Box 5050
Burlington, Ont.
L7R 4A6

ET 017A

The formulation of an integrated set of computer-based tools which will allow the systematic planning and evaluation of municipal sewage collection and treatment facilities is the objective of this project. The software will then be demonstrated in a case study at Port Colborne, Ont.

Further Development of the Rayox® Enhanced Oxidation Product

Solarchem Enterprises Inc.
Dr. Stephen Cater

(416) 764-9666

Unit 5, 40 West Wilmot St.
Richmond Hill, Ont.
L4B 1H8

ET 024

Removal of organic pollutants from the aquatic environment using the Rayox® enhanced oxidation technology involves using high-powered ultraviolet lamps, with oxidants, which cause the generation of reactor intermediates such as the hydroxyl radical, leading to mineralization to harmless substances. Treatment of a variety of contaminated waters have been examined, including process wastewater and groundwater. Excellent results have been obtained to date even in the most problematic process waters. Such compounds as chlorinated organics, aromatic hydrocarbons, N-Nitrosodimethylamine and pentachlorophenol can all be readily reduced to or below required discharge levels. Research and development is focussing on physical and chemical process improvements to reduce the overall costs of treating contaminated water.

Hard Metal, High Efficiency Sludge Handling Pump

Hayward Gordon Ltd.
Mr. John Hayward

(416) 677-6400

7505 Bath Rd.
Mississauga, Ont.
L4T 1L3

ET 036A

This undertaking involves the design, development and field evaluation of eleven models (horizontal, vertical dry pit and immersible configurations) of a hard metal, screw impeller centrifugal pump to be used for handling both sewage and sludge in municipal and industrial wastewater treatment plants. This may lead to development of a superior system for the transfer of heavier and grittier municipal and industrial waste sludges and contribute to the more efficient and economic operation of wastewater treatment plants.

Catalysed Reductive Degradation of Halogenated Organic Compounds

Waterloo Centre for Groundwater Research
University of Waterloo
Dr. Robert Gillham

(519) 888-4658

Waterloo, Ont.
N2L 3G1

ET 074

Halogenated organic compounds are a major threat to the water environment. A cost-effective method based on reductive dehalogenation with metal surfaces acting as a catalyst for the removal of halogenated organic compounds from water is being investigated in this project. This could be an alternative to such processes as activated carbon adsorption or aeration. Through laboratory and field testing, a system having application in such areas as remediation of existing zones of groundwater contamination and the removal of trihalomethanes from chlorinated municipal water supplies is being developed.

WATER AND SEWAGE TREATMENT

Development of Continuous Preparation of Activated Silica

National Silicates Ltd.
Mr. Stephen Gibson

(416) 255-7771

429 Kipling Ave.
Toronto, Ont.
M8V 3S7 ET 132

Under development in this project is a process for the continuous preparation of activated silica, an effective inorganic coagulant aid. Activated silica is produced through the polymerization of sodium silicate with a variety of activating agents. It has been demonstrated as an effective coagulant aid in the reduction of total phosphorus discharges from sewage treatment plants and other industrial institutions. Successful development of an on-site production process that is practical and economical would enable the manufacture of an alternative to organic polyelectrolytes for use in potable, sewage and industrial wastewater treatment.

Wastewater Aerator Prototype

Aqua Aeration Systems Inc.
Mr. Andrew Jankowski

(416) 338-9237

3221 Valmarie Ave.
Mississauga, Ont.
L5C 2A4 ET 135

The fabrication and installation at a sewage plant of a full-scale prototype aerator design consisting of a multi-bladed conical configuration enclosed in a similarly conical encasement is the focus of this venture. The aerator functions by drawing in and mixing atmospheric air from above the liquid. Its efficiency is such that it can function effectively without the need for a supplementary supply of air. When installed in existing wastewater treatment facilities, the aerator would have the capability to simultaneously increase capacity and reduce operating costs through reduced energy and maintenance requirements.

Development of Sealable-Joint Sheet Pile Cutoff Walls for Groundwater Remediation

Waterloo Centre for Groundwater Research
University of Waterloo
Dr. John Cherry

(519) 888-4516

Waterloo, Ont.
N2L 3G1 ET 143

The development and production of modified steel sheet pile sections and selection of sealants for use in construction of low permeability walls has been the objective of this project. This new sheet piling differs from conventional sheet piling in that the joints can be sealed after the wall has been driven into the ground. Leakage from contained soil has been shown to be reduced to such a low value that these sheet pile cutoff walls appear suitable for a wide variety of environmental control purposes, including as a relatively low cost containment system in "pump and treat" remediation programs at contaminated sites.

Demonstration and Full-Scale Testing of a New Thermal Chemical Reduction Process for Remediation of Hamilton Harbour Sediments

EcoLogic International Inc.
Dr. Douglas Hallet

(519) 856-9591

143 Dennis St.
Rockwood, Ont.
N0B 2K0

ET 153

This developmental work has been an examination at the laboratory and pilot scale of the effectiveness of a new thermo-chemical reduction process for the destruction of such contaminants as polyaromatic hydrocarbons, polychlorinated biphenyls and other organic compounds in harbour sediments. The technology has also been assessed at the bench scale for the destruction of such pure compounds as polychlorinated biphenyls and tri- and hexachlorobenzene. Based on such criteria as destruction efficiency, non-formation of dioxins and furans, suitability for aqueous wastes, mobility and cost, this process appears suitable for application in a wide range of organic hazardous waste problems.

Development of a Process which will Reclaim Scrap and Produce New Products for Interior and Exterior Architectural Applications

Plastiglas Industries Ltd.
Mr. Stephen Baker

(416) 428-2002

403 Clements Rd. W.
Ajax, Ont.
L1S 6N3 ET 029

Fibreglass reinforced products cannot presently be recycled. The objective of this project is the development of a new process for the recovery of fibres from fibreglass-reinforced plastic scrap and their incorporation into such new products as interior and exterior building materials, or furniture. When fully operational, the company would be able to recover much of their scrap and that from other fibreglass manufacturers diverting a significant quantity of material from landfill sites.

Development of Mercury Free Reusable Alkaline Manganese Dioxide (RAM) Consumer Batteries

Battery Technologies Inc.
Dr. Klaus Tomantschger

(416) 820-1755

2480 Dunwin Dr.
Mississauga, Ont.
L5L 1J9 ET 048

The development of mercury free RAM battery technology for use in small format consumer battery sizes (AAA, AA, C, D) is being accelerated in this project. The emphasis is on the further development and refinement of the technology to produce a rechargeable alkaline AA battery which is free of mercury, and with performance and cost comparable to existing single use alkaline batteries. Use of such batteries would greatly reduce the estimated 13 tonnes of mercury disposed of annually into the Canadian environment through the disposal of small format batteries into landfill sites and incinerators.

RMDC Roofing Shingles Recycling

Roofing Materials Disposal Company Ltd.
Mr. Keith Beare

(416) 336-7575

247 Elmhurst Cres.
Burlington, Ont.
L7L 2A5 ET 052

The objective of this project is the development of a small portable processing plant for the recycling of roofing shingle waste. Based on an auger extruder, the plant will mechanically disintegrate roofing waste and homogenize it into a bituminous raw material. The material formed, asphalt composition mix, could then be marketed as a roading material or formed into such products as paving stones. Successful introduction of this technology could divert as much as 500,000 tonnes of waste from landfills in Canada each year.

Deinking of Wastepaper by High Pressure Steam Treatment for Paper Reuse

Stake Technology Ltd.
Dr. Ernest Yu

(416) 455-1990

2838 Highway 7
Norval, Ont.
L0P 1K0

ET O68

The feasibility of continuous steam-explosion treatment in the deinking of selected wastepapers for paper recycling is being assessed in this project. Studies at both the laboratory and pilot scale have suggested numerous technical and economic benefits compared with conventional processes. Using this technology, enhanced ink removal from paper fibres appears possible with reduced or even no use of deinking chemicals. The overall greater cleanliness of the fibres would also likely reduce the requirement for downstream cleaning after pulping. These benefits have been demonstrated for a wide range of paper types including coated magazines, office waste and old corrugated containers.

Proactive Printer's Waste Ink Recycling, Phase II & III

Proactive Recycling Inc.
Mr. Bert Wakeford

(519) 371-6511

235 10th St. W.
Owen Sound, Ont.
N4K 2R3

ET 080

This project is centred on the further development and application of a self-sufficient, mobile ink recycling unit capable of on-site filtering and processing. The compact prototype could be transported to the site of waste generation and produce economically viable daily quantities of recycled ink. It will be able to produce recycled ink with characteristics approaching those of virgin product and ensure full four colour recycling. This could facilitate up to 95% reduction in the amount of hazardous liquid waste ink requiring disposal.

ANALYTICAL INSTRUMENTATION

Development of a Nitrogen-Specific GC/Detector for Measurement of Atmospheric Nitrates

Unisearch Associates Inc.
Dr. John Drummond

(416) 669-3547

222 Snidercroft Rd.
Concord, Ont.
L4K 1B5

ET 066

This project involves the development, construction, testing and evaluation of a market-ready nitrogen specific gas chromatograph/detector designed for the sensitive and selective measurement of organic nitrates and mutagenic nitro-polyaromatic hydrocarbons. Applications for the instrument would include the measurement of a variety of atmospheric pollutants that are linked to oxidant formation in the atmosphere, the analysis of nitrosamines in food and the detection of explosives.

Development of Supercritical Fluid Extraction (SFE) with Ion Mobility Detector (IMD) for Qualitative Prescreening for Environmental Contaminants

Pylon Electronic Development Co. Ltd.
Dr. Frank Bales

(613) 226-7920

147 Colonnade Rd.
Nepean, Ont.
K2E 7L9

ET 094

The integration, development and testing of the technologies of Ion Mobility Detection and Supercritical Fluid Extraction to construct a self-contained, field portable and cost effective extraction instrument is the focus of this study. This tool could be used to extract, concentrate and qualitatively analyze numerous organic contaminants occurring in most environmentally sensitive effluents and other matrices.

TIRE TECHNOLOGIES

Transportable Tire Shredder

Shred-Tech Ltd.
Mr. John Bell

(519) 621-3560

201 Beverly St.
P.O. Box 1508
Cambridge, Ont.
N1R 7G8

ET 179

This venture involves the design, development, testing and demonstration of a transportable tire shredder that can be operated at remote locations and smaller landfill sites where permanent installations are not feasible. This would offer an alternative approach to shipping whole tires to central shredding sites. Capabilities of the shredder will include single person operation, extended knife life, the ability to handle both car and truck tires and the ability to ensure 2 to 4" shred size if required in order to make fuel chips for export. Following laboratory testing, the machine will be made available to various landfill sites in Ontario for practical demonstration.

Preparing of New Thermo Plastic Compounds Containing Ground Rubber Tires

Department of Chemistry
Queen's University
Dr. Warren Baker

(613) 545-2621

Kingston, Ont.
K7L 3N6

ET 226

The preparation of thermoplastic compounds containing maximum amounts of ground rubber tires that could be processed into cost effective finished products is the objective of this study. Initially, characteristics of ground rubber from different sources and processes and how their surface and bulk properties can be modified advantageously are being assessed. Accompanying this is an examination of the compounding of ground rubber with several virgin plastic polyethylene polymers. This project will provide scientific information and technical support to Ontario industries pursuing new market and new product opportunities for scrap tires.

AIR POLLUTION CONTROL

Development of Differential Optical Absorption Spectroscopy System (DOAS) for Air Monitoring and Measurement

Unisearch Associates Inc.
Dr. Gervase Mackay

(416) 669-3547

222 Snidercroft Rd.
Concord, Ont.
L4K 1B5

ET 136

The objective of this project is the development of a commercial, mobile instrument based on differential optical absorption spectroscopy capable of measuring air pollutants automatically, simultaneously and continuously with high sensitivity and selectivity. The instrument could be used either in a remote sensing mode suitable for plume or air quality measurements or in situ measurements such as stack monitoring. It would also have application in field studies including that of oxidant chemistry to measure key atmospheric species, including a number, such as NO_3, which cannot be measured by any other method.

NOTE: There were no active projects in the socio-economic analysis category during the year.